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Part III

Environmental Protection Agency

Water Quality Criteria; Availability

ENVIRONMENTAL PROTECTION AGENCY

[FRL 1255-4A]

Water Quality Criteria; Availability

AGENCY: Environmental Protection Agency.

ACTION: Notice of availability.

SUMMARY: EPA is announcing the availability for public comment of water quality criteria for 26 of the remaining 38 of the 65 pollutants listed as toxic under the Clean Water Act (CWA). When published in final after public comment, these water quality criteria may form the basis for enforceable standards. The criteria were developed pursuant to section 304 of the CWA and in compliance with a court order. Summaries of both aquatic-based and health-based criteria and the criteria formulation sections of the documents are published below. We anticipate publishing criteria for the remaining 12 toxic pollutants within the next 30 days.

DATES: Written comments should be submitted to the person listed below by October 23, 1979.

FOR FURTHER INFORMATION CONTACT: Kenneth M. Mackenthun, Director, Criteria and Standards Division (WH-585), Office of Water Planning and Standards, U.S. Environmental Protection Agency, 401 M Street SW., Washington, D.C. 20460, telephone 202/755-0100.

SUPPLEMENTAL INFORMATION: EPA published 27 water quality criteria for public comment on March 15, 1979, (44 FR 15926). At that time EPA published a preamble for the criteria, a methodology for deriving aquatic life criteria, a methodology for deriving human health criteria, a summary of specific issues for commenters to address and summaries of the individual criteria documents. The information contained in the March 15 publication applies to the criteria published in this notice.

AVAILABILITY OF DOCUMENTS: Copies of the complete documents will be sent to all persons who requested copies of the initial criteria prior to the time they were published and to those who commented on the first 27 criteria. When ordering documents from this source, please specify the PB number for each document. These are listed at the end of this document. Other persons wishing to review the full documents may obtain copies from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia (703) 557-4650. The documents also are available for public inspection and copying during normal business hours at: Public Information Reference Unit, U.S. Environmental Protection Agency, Room 2404 (rear), 401 M Street SW., Washington, D.C. 20460. As provided in 40 CFR Part 2, a reasonable fee may be charged for copying services. Copies of these documents will also be available for review in the EPA Regional Office libraries.

Dated: June 29, 1979.

Barbara Blum,

Acting Administrator.

Acenaphthene

Criteria Summary

Freshwater Aquatic Life. The data base for freshwater aquatic life is insufficient to allow use of the Guidelines. The following recommendation is inferred from toxicity data for saltwater organisms.

For acenaphthene the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 110 μg/l as a 24-hour average and the concentration should not exceed 240 μg/l at any time.

Saltwater Aquatic Life. For acenaphthene the criterion to protect saltwater aquatic life as derived using the Guidelines is 7.5 μg/l as a 24-hour average and the concentration should not exceed 17 μg/l at any time.

Human Health. For the protection of human health from the toxic properties of acenaphthene, the ambient water criterion is determined to be 20 μg/l.

Basis for the Criteria

Freshwater Aquatic Life. No freshwater criterion can be derived for acenaphthene using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available.

Results obtained with acenaphthene and saltwater organisms indicate how a criterion may be derived.

For acenaphthene and saltwater organisms, 0.44 times the Final Acute Value is less than the Final Chronic Value which is derived from results of an embryo-larval test with the sheepshead minnow. Therefore, it seems reasonable to estimate a criterion for acenaphthene and freshwater organisms using 0.44 times the Final Acute Value.

The maximum concentration of acenaphthene is the Final Acute Value of 240 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For acenaphthene the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 110 μg/l as a 24-hour average and the concentration should not exceed 240 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 240 μg/l
Final Invertebrate Acute Value = 1,700 μg/l
Final Acute Value = 240 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 520 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 520 μg/l
0.44 × Final Acute Value = 110 μg/l

Saltwater Aquatic Life. The maximum concentration of acenaphthene is the Final Acute Value of 17 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For acenaphthene the criterion to protect saltwater aquatic life as derived using the Guidelines is 7.5 μg/l as a 24-hour average and the concentration should not exceed 17 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 330 μg/l
Final Invertebrate Acute Value = 17 μg/l
Final Acute Value = 17 μg/l
Final Fish Chronic Value = 53 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 500 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 53 μg/l
0.44 × Final Acute Value = 7.5 μg/l

Human Health. So little research has been performed on acenaphthene that its mammalian and human health effects are virtually unknown. The two toxicity studies available (Knobloch, et al. 1969; Reshetyuk, et al. 1970) are inadequate for the basis of a criterion due to the experimental designs (lack of controls, small number of animals, etc.) Therefore, until more toxicological data are generated, particularly teratogenic data in view of the effects of acenaphthene on cell division, an interim criterion based upon organoleptic data is proposed. The lowest human responses were reported at 0.022 to 0.22 ppm (Lillard and Powers, 1975), and thus 20 μg/l is the

recommended criterion. It must be emphasized, however, that this value is not related to health effects and that the significance of odor thresholds is unknown. This value will need to be reviewed once more toxicological data are available.

Acrolein

Criteria Summary

Freshwater Aquatic Life. For acrolein the criterion to protect freshwater aquatic life as derived using the Guidelines is 1.2 μg/l as a 24-hour average and the concentrations should not exceed 2.7 μg/l at any time.

Saltwater Aquatic Life. The data base for saltwater aquatic life is insufficient to allow use of the Guidelines. The following recommendation is inferred from toxicity data for freshwater organisms.

For acrolein the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 0.88 μg/l as a 24-hour average and the concentration should not exceed 2.0 μg/l at any time.

Human Health. For the protection of human health from the adverse effects of acrolein ingested through the consumption of water and fish a criterion of 6.5 μg/l is suggested.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of acrolein is the Final Acute Value of 2.7 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For acrolein the criterion to protect freshwater aquatic life as derived using the Guidelines is 1.2 μg/l as a 24-hour average and the concentration should not exceed 2.7 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value=10 μg/l
Final Invertebrate Acute Value=2.7 μg/l
Final Acute Value=2.7 μg/l
Final Fish Chronic Value=3.3 μg/l
Final Invertebrate Chronic Value=4.7 μg/l
Final Plant Value=not available
Residue Limited Toxicant
Concentration=not available
Final Chronic Value=3.3 μg/l
0.44×Final Acute Value=1.2 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for acrolein using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available.

Results obtained with acrolein and freshwater organisms indicate how a criterion may be estimated.

For acrolein and freshwater organisms 0.44 times the Final Acute Value is less than the Final Chronic Value which is derived from results of a life cycle test with the fathead minnow. Therefore, it seems reasonable to estimate a criterion for acrolein and saltwater organisms using 0.44 times the Final Acute Value.

The maximum concentration of acrolein is the Final Acute Value of 2.0 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For acrolein the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 0.88 μg/l as a 24-hour average and the concentration should not exceed 2.0 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value=41 μg/l
Final Invertebrate Acute Value=2.0 μg/l
Final Acute Value=2.0 μg/l
Final Fish Chronic Value=not available
Final Invertebrate Chronic Value=not available
Final Plant Value=not available
Residue Limited Toxicant
Concentration=not available
Final Chronic Value=not available
0.44×Final Acute Value=0.88 μg/l

Human Health. Although acrolein is mutagenic in some test systems (see "Mutagenicity" section) and can bind to mammalian DNA (see "Acute Effects on Experimental Systems" section), current information indicates that acrolein is not a carcinogen or cocarcinagen ("Carcinogenicity" section). Water quality criteria for acrolein could be derived from the TLV, chronic inhalation studies, and subacute oral studies using noncarcinogenic biological responses.

Stokinger and Woodward (1958) have described a method for calculating water quality criteria from TLV's. Essentially, this method consists of deriving an acceptable daily intake (ADI) for man from the TLV by making assumptions on breathing rate and absorption. The ADI is then partitioned into permissible amounts from drinking water and other sources. However, because the TLV is based on the prevention of the irritant effects of acrolein on inhalation exposures, such a criterion would have little, if any, validity.

A criterion could also be calculated based on chronic inhalation data. As summarized in the "Chronic Toxicity to Experimental Animals" section, female hamsters exposed to acrolein at 9.2 mg/m^3 in the air, seven hours per day, five days per week, for 52 weeks evidenced slight hematologic changes, significant decreases in liver weight, and significant increases in lung weights (Feron and Kruysse, 1977).

This study cannot be used to derive a criterion by standard methods because a no observable effect level (NOEL) was not obtained. Nonetheless, by making assumptions of respiratory volume and retention, the exposure data from this study can be converted to a mg/kg dose and an "equivalent" water exposure level can be calculated. The average body weight for the hamsters at the end of the exposure was about 100 g. Assuming a mean minute volume of 33 ml for a 100 g hamster (Robinson, 1968) and a retention of 0.75, the average daily dose is estimated at 68.3 μg/animal (9.2 mg acrolein/m^3×0.033 1/min×1 m^3/1000 liters×60 min/hour×7 hours/day×5 days/7 days×0.75) or 683 μg/kg. Using an uncertainty factor of 1000 (NAS, 1977, p. 108), an estimated "unacceptable" daily dose for man is 0.683 μg/kg or 47.8 μg/man, assuming a 70-kg body weight.

A criterion based on this daily dose level would be unsatisfactory for two reasons. First, as indicated above, the dose data used to derive the standard are not based on a NOEL. In this respect, the derived criterion represents an undesirably high level in water. Secondly, the criterion is based on an inhalation study. Given the probable instability of acrolein in the gastrointestinal tract, the use of inhalation data may not be suitable for deriving a criterion.

In Drinking Water and Human Health, the National Academy of Sciences (NAS, 1977) summarized the study by Newell (1958) in which acrolein was added to the drinking water of rats at concentrations of 5, 13, 32, 80, and 200 mg/l for 90 days without apparent adverse effects (see "Subacute Toxicity to Experimental Animals" section). Because this study did not involve a chronic exposure, the National Academy of Sciences (1977) declined to derive an acceptable daily intake for man based on this study. However, McNamara (1976) has suggested that subacute exposures can be used to estimate chronic no-effect levels. Based on an extensive review of the literature comparing subacute and chronic toxicity

tests, McNamara (1976) noted that "for 95 percent of chemical compounds . . . (on which data were available) . . . a three-month no-effect dose/ten will produce no effects in a lifetime." Using this approximation for acrolein, the no-observable-effect level for acrolein on rats can be estimated at 20 mg/l of water. Assuming a daily water consumption of 35 ml/day and a body weight of 450 g (ARS Sprague-Dawley, 1974), the chronic no-effect dose for rats is estimated at 1.56 mg/kg. This value may be converted into an ADI for man by applying an uncertainty factor. Since the chronic no-effect dose is merely an estimate based on observed relationships between subacute and chronic toxicity, an uncertainty factor of 1000 is recommended (see NAS, 1977, p. 804). Thus, the estimated ADI for man is 15.6 μg/kg or 109 μg/man, assuming a 70-kg body weight. Therefore, consumption of 2 liters of water daily and 18.7 grams of contaminated fish having a bioconcentration factor of 790, would result in, assuming 100 percent gastrointestinal absorption of acrolein, a maximum permissible concentration of 6.50 μg/l for the ingested water:

$$\frac{109\ \mu g}{(2\ \text{liters} + (790 \times 0.018) \times 1.0} = 6.50\ \mu g/l$$

This criterion does not consider other significant sources of exposure to acrolein such as inhalation. In addition, this criterion may be above the organoleptic level for acrolein, which has not been determined in man.

Antimony

Criteria Summary

Freshwater Aquatic Life. For an antimony the criterion to protect freshwater aquatic life as derived using the Guidelines is 120 μg/l as a 24-hour average and the concentration should not exceed 1,000 μg/l at any time.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for antimony can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. For the protection of human health from the adverse effects of antimony ingested through the consumption of contaminated water and fish a criterion of 145 μg/l is suggested.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of antimony is the Final Acute Value of 1,000 μg/l and the 24-hour average concentration is the Final Chronic Value of 120 μg/l. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For antimony the criterion to protect freshwater aquatic life as derived using the Guidelines is 120 μg/l as a 24-hour average and the concentration should not exceed 1,000 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures. All concentrations herein are expressed in terms of antimony.

Final Fish Acute Value = 5,600 μg/l
Final Invertebrate Acute Value = 1,000 μg/l
Final Acute Value = 1,000 μg/l
Final Fish Chronic Value = 120 μg/l
Final Invertebrate Chronic Value = 1,000 μg/l
Final Plant Value = 610 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 120 μg/l
0.44 × Final Acute Value = 400 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for antimony using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data. The concentrations below have been rounded to two significant figures. All concentrations herein are expressed in terms of antimony.

Final Fish Acute Value = not available
Final Invertebrate Acute Value = not available
Final Acute Value = not available
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = greater than 4,200 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = greater than 4,200 μg/l
0.44 × Final Acute Value = not available

Human Health. At the present time, there are essentially no existing community epidemiology studies that provide information on health effects associated with antimony exposure among the general population of the United States or other countries. This is primarily due, as indicated earlier, to the lack of any recognizable public health problems having been previously associated with environmental exposures to antimony. Rather, one is limited to extrapolating, as best as can be done, from human occupational health and animal toxicology studies.

Pulmonary, cardiovascular, dermal, and certain effects on reproduction, development, and longevity are among the health effects best associated with antimony exposure. The pulmonary effects, however, are almost exclusively associated with inhalation exposures and have much less relevance than the other effects in considering possible bases for development of criteria for a water standard. The pulmonary effects are, therefore, not considered here, but rather the main emphasis is placed on the latter types of effects listed.

Cardiovascular changes have been well associated with exposure to antimony and probably represent the most serious antimony-related human health effects demonstrated thus far. Specifically, in humans, various ECG changes e.g., altered T-wave patterns, have been consistently observed following exposures to either trivalent or pentavalent antimonial compounds and have been interpreted as being indicative of at least temporary cardiotoxic effects of antimony. Indications of even more severe, possibly permanent myocardial damage in humans have been obtained in the form of histopathological evidence of cardiac edema, myocardial fibrosis, and other signs of myocardial structural damage. Parallel findings of functional changes in ECG patterns and of histopathological evidence of myocardial structural damage have also been obtained in animal toxicology studies using controlled exposures to antimony compounds.

As for the other types of effects reasonably well associated with antimony exposures, only very limited data exist regarding such effects, and they are presently insufficient to allow definitive conclusions to be drawn regarding important exposure parameters determining their induction in humans. For example, certain skin irritation effects, e.g., rashes, have been noted to occur with high levels of occupational antimony exposure, especially under conditions of extreme heat; similar dermal effects have been reported for at least some patients undergoing therapeutic treatments with systemic injections of antimonials. There does yet exist, however, any evidence to suggest that dermal effects would result from oral ingestion of antimony compounds. In regard to effects on reproduction, development, and longevity, the available evidence linking such effects to antimony is almost entirely derived from animal toxicology studies and consists primarily of data suggesting that: (1) prenatal exposures can interfere with conception, (2) chronic oral exposure via feeding can result in postnatal retardation of growth as indexed by body weight gain, and (3) chronic oral

exposure via drinking water can induce alterations in certain blood chemistry parameters and significantly shorten survival time or lifespan. Such effects, however, have not yet been well replicated in other animal studies; and only very limited analogous antimony-induced effects on reproduction have yet been demonstrated to occur in humans.

In summary, myocardial effects are among the most serious and best characterized human health effects that can presently be linked with antimony exposure; as such, setting an ambient water criterion predicated on protecting the general public from antimony-induced myocardial effects is the most desirable course of action if sufficient information on dose-effect relationships for myocardial effects exists. Failing that, then, the very limited animal toxicology literature on reproduction, development, and longevity effects would offer an alternative basis.

Dose-Effect/Dose-Response Relationships. The previous section summarizes the very limited information presently available regarding a qualitative description of adverse health effects associated with antimony exposure. Ideally, the main objective of the present section would be to provide further information regarding the characterization of dose-effect/dose-response relationships that hold for the induction of the key health effects expected to provide a basis for setting a criterion for antimony. In regard to the definition of "dose-effect" and "dose-response" relationships, Pfitzer (1976) explains the distinction between effect and response in the following terms: "Effect is taken to indicate the variable change due to a dose in a specific subject; and "response" is the number of individuals in a group showing that effect, i.e., the number of "reactors" showing a specific effect at a particular defined dose level. Unfortunately, it is virtually impossible to characterize key antimony-induced health effects in such quantitative terms due to the very limited data base that presently exists.

For example, data reported for the studies by Brieger et al. (1954) suggest an inhalation no-effect level for myocardial effects as likely being around 0.5 mg/m^3. Air concentrations of antimony trisulfide ranging from 0.56 to 5.5 mg/m^3 (with most 3.0 mg/m^3) were associated with the induction of altered ECG patterns and some deaths attributed to myocardial damage among certain antimony workers (Brieger, et al. 1954). Also, in parallel studies on animals, Brieger, et al. (1954), observed ECG alterations in rats and rabbits at antimony exposures of 3.1 to 5.6 mg/m^3, confirming that antimony, per se can specifically produce myocardial effects of the type observed with the occupational exposures. Unfortunately, for present purposes, however, no adequate data exist on oral exposures to antimony compounds which would support reasonable estimates regarding likely no-effect levels for the induction of myocardial effects via antimony ingestion. Nor is there sufficient information on relative absorption rates following oral or inhalation exposures to antimony to allow for extrapolation of likely dose-effect relationships for oral exposures from the limited inhalation exposure data. Consequently, it is presently impossible to recommend a water criterion level based on projected no-effect levels for myocardial damage.

In the absence of sufficient information to develop a criterion based on known antimony myocardial effects in humans, the most viable alternative is to focus on animal toxicology studies demonstrating antimony-induced effects on reproduction, development, and longevity. From the animal studies, those pertaining to prenatal reproductive effects, e.g., Belyaeva (1967) and Casals (1972), employed inhalation exposures or systemic injections of antimony compounds, and their result cannot presently be extrapolated very well to project the likely impact of oral exposures. Similarly, the few human studies where effects on reproduction were reported (Belyaeva, 1965; Aiello, 1955) deal with inhalation exposures in occupational settings and cannot now be used to extrapolate likely oral exposure no-effect levels.

Turning to effects on postnatal development and longevity, a study by Gross, et al. (1955) presents evidence for growth retardation occurring when rats were chronically fed diets containing two percent antimony trioxide, but a no-effect level for growth retardation cannot be deduced from the results reported. The studies by Schroeder (Kanasawa and Schroeder, 1969; Schroeder, et al. 1970) containing data on antimony effects on growth and longevity, on the other hand, indicate that oral exposure to 5 ppm of antimony in drinking water had no effect on the rate of growth of either rats or mice. The 5 ppm exposure level, however, was effective in producing significant, although relatively slight reductions in lifespans for animals of both species and altered blood chemistries for exposed rats. It is, therefore, recommended that the 5 ppm exposure level producing such effects be taken as a "lowest observed effect level" (LOEL) in animals that likely approximates the "no-effect" level for antimony induced effects on growth and longevity. If one calculates acceptable daily intake for man using the value of 5 mg/l of antimony and the uncertainty factor of 100 in view of no presently available human epidemiological data regarding such effect would result in a recommended criterion of 145 μg/l.

$$\text{Dose/day} = \frac{5\ (\text{mg/l}) \times 25\ \text{ml/day/rat})}{0.3\ \text{kg/rat}}$$

$$= 416.67(\mu\text{g/kg/day})$$

$$\frac{416}{100} = 4.16 = 4.2\ (\mu\text{g, ADI})$$

$4.2 \times 70 = 294$ μg (ADI for 70 kg/man)
2 (X) + (Average fish intake) (F) (X) = Daily intake
2 (X) + (0.0187) (1.4.) (X) = 294
99% 1%
2.0262 (X) = 294
(X) = 145 ug/l
(criterion)
100 = uncertainty factor
2 = amount of water ingested, l/day
X = antimony concentration, mg/l
0.0187 = amount of fish/shellfish products consumed, kg/day

$$F = \frac{1.4\ \text{mg.sb/kg fish}}{\text{mg.sb/l of water}}$$

= Bioconcentration factor (BCF)

Drinking water contributes 99 percent of the assumed exposure while eating contaminated fish products accounts for one percent. The criterion level for antimony in ambient water can alternatively be expressed as 11 mg/l, if exposure is assumed to be from the consumption of fish and shellfish alone.

$X + 0.0187 \times 1.4 = 294$
$X = 0.0262 \times 294$
$X = 11.308$
$X = 11$ (mg/l)

Chlorinated Phenols

Criteria Summary

Freshwater Aquatic Life. For 4-chlorophenol the criterion to protect freshwater aquatic life as derived using the Guidelines is 45 μg/l as a 24-hour average and the concentration should not exceed 180 μg/l at any time.

For 2,4,6-trichlorophenol the criterion to protect freshwater aquatic life as derived using the Guidelines is 52 μg/l as a 24-hour average and the concentration should not exceed 150 μg/ l at any time.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for any chlorinated phenol can be derived using the Guidelines, and there are insufficient

data to estimate a criterion using other procedures.

Human Health. For the protection of human health from the adverse effects of chlorinated phenols in water, the following criteria are recommended:

Monochlorophenols

3-chlorophenol—50 μg/l
4-chlorophenol—30 μg/l

Dichlorophenol

2,5-dichlorophenol—3.0 μg/l
2,6-dichlorophenol—3.0 μg/l

Trichlorophenol

2,4,5-trichlorophenol—10 μg/l
2,4,6,-trichlorophenol—100 μg/l

Tetrachlorophenol *

2,3,4,6-tetrachlorophenol—263 μg/l

Basis for the Criteria

Freshwater Aquatic Life. Flavor impairment studies with rainbow trout exposed to various chlorinated phenols showed tainting occurred from 23 μg/l to 84 μg/l and tainting will become the basis for criteria. Criteria can be calculated only for 4-chlorophenol and 2,4,6-trichlorophenol since those are the only two chlorinated phenols for which both acute toxicity data and tainting data exist. Tainting was not caused by 4-chlorophenol and 2,4,6-trichlorophenol at 45 μg/l and 52 μg/l, respectively, and these concentrations are the 24-hour average concentrations. The maximum concentrations of 4-chlorophenol and 2,4,6-trichlorophenol are the Final Acute Values of 180 and 150 μg/l respectively.

No freshwater criterion can be derived for other chlorinated phenols using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

For 2,4,6-trichlorophenol the criterion to protect freshwater aquatic life as derived using the Guidelines is 52 μg/l as a 24-hour average and the concentration should not exceed 150 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

4-chlorophenol

Final Fish Acute Value = 540 μg/l
Final Invertebrate Acute Value = 180 μg/l
Final Acute Value = 180 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 4,800 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 45 μg/l for tainting
0.44 × Final Acute Value = 79 μg/l

2,4,6,-trichlorophenol

Final Fish Acute Value = 150 μg/l
Final Invertebrate Acute Value = 240 μg/l
Final Acute Value = 150 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 5,900 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 52 μg/l for tainting
0.44 × Final Acute Value = 66 μg/l

4-chloro-3-methylphenol

Final Fish Acute Value = 5.4 μg/l
Final Invertebrate Acute Value = not available
Final Acute Value = 5.4 μg/l
Final Fish Chronic Value = not available.
Final Invertebrate Chronic Value = not available
Final Plant Value = 95,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 95,000 μg/l
0.44 × Final Acute Value = 2.4 μg/l

4-chloro-2-methylphenol

Final Fish Acute Value = 330 μg/l
Final Invertebrate Acute Value = 12 μg/l
Final Acute Value = 12 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 93,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 93,000 μg/l
0.44 × Final Acute Value = 5.3 μg/l

2,4-dichloro-6-methylphenol

Final Fish Acute Value = 230 μg/l
Final Invertebrate Acute Value = 17 μg/l
Final Acute Value = 17 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = not available
0.44 × Final Acute Value = 7.5 μg/l

2,4,5-trichlorophenol

Final Fish Acute Value = 63 μg/l
Final Invertebrate Acute Value = 110 μg/l
Final Acute Value = 63 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 1,200 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 1,200 μg/l
0.44 × Final Acute Value = 28 μg/l

2,3,4,6-tetrachlorophenol

Final Fish Acute Value = 20 μg/l
Final Invertebrate Acute Value = 12 μg/l
Final Acute Value = 12 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 600 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 600 μg/l
0.44 × Final Acute Value = 5.3 μg/l

2,3,5,6-tetrachlorophenol

Final Fish Acute Value = 24 μg/l
Final Invertebrate Acute Value = 23 μg/l
Final Acute Value = 23 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 2,700 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 2,700 μg/l
0.44 × Final Acute Value = 10 μg/l

Saltwater Aquatic Life. Flavor impairment studies with aquatic organisms indicate that flavor impairment may be an especially important factor in determining water quality criteria for chlorophenols. Unfortunately, data necessary to establish a saltwater criterion based on tainting are unavailable.

For saltwater aquatic life, no criterion for any chlorinated phenol can be derived using the Guidelines, and there are insufficient data to establish a criterion using other procedures.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

4-chlorophenol

Final Fish Acute Value = 790 μg/l
Final Invertebrate Acute Value = 510 μg/l
Final Acute Value = 510 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 3,300 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 3,300 μg/l
0.44 × Final Acute Value = 220 μg/l

2,4,5-trichlorophenol

Final Fish Acute Value = 250 μg/l
Final Invertebrate Value = 66 μg/l
Final Acute Value = 66 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 890 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 890 μg/l
0.44 × Final Acute Value = 29 μg/l

2,3,5,6-tetrachlorophenol

Final Fish Acute Value = 280 μg/l
Final Invertebrate Acute Value = 380 μg/l
Final Acute Value = 280 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 440 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 440 μg/l
0.44 × Final Acute Value = 120 μg/l

*This criterion is based on toxicological effects; all other criterion are based on organoleptic effects.

2,4-dichloro-6-methylphenol

Final Fish Acute Value = not available
Final Invertebrate Acute Value = not available
Final Acute Value = not available
Final Fish Chronic Value = less than 27 µg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant Concentration = not available
Final Chronic Value = less than 27 µg/l
0.44 × Final Acute Value = not available

Human Health. The chlorinated phenols which are the subject of this document are the monochlorophenols (3- and 4-chlorophenol); the dichlorophenols (2,5-; 2,6-; 2,3-; 4,6-; and 3,4-dichlorophenols) the trichlorophenols (2,4,5-; 3,4,5-; 2,4,6-; 2,3,4-; 2,3,5-; and 2,3,6-trichlorophenol) and the tetrachlorophenols (2,3,4,5-; 2,3,4,6-; and 2,3,5,6-tetrachlorophenols). In addition, the monochlorocresols are discussed.

Three chlorinated phenols have been the subject of separate criteria documents: 2-chlorophenol, 2,4-dichlorophenol and pentachlorophenol.

There are very little data on most of these compounds on chronic mammalian effects. However, the organoleptic effects of these compounds have been well documented (table 1).

There are toxicity data on 2,4,5-trichlorophenol.

McCollister, et al. (1961), in a 98 day feeding study on rats, demonstrated the No Observable Effect Level (NOEL) for 2,4,5-trichlorophenol to be 100 mg/kg. Using the National Academy of Sciences' recommended uncertainty factor of 1000 (Drinking Water and Health, 1977) the Acceptable Daily Intake (ADI) is calculated to be 0.1 mg/kg of body weight, or 7 mg for a 70 kg person.

For the sake of establishing water quality criteria, it is assumed that on the average a person ingests 2 liters of water and 18.7 grams of fish. Since fish may bioaccumulate substances, a bioconcentration factor (BCF) is used in the calculation. The BCF for 2,4,5-trichlorophenol is 130 and was derived by U.S. EPA ecological laboratories in Duluth, Minnesota.

The equation for calculating an acceptable amount of 2,4,5-trichlorophenol in water based on the ingestion of 2 liters of drinking water and 18.7 grams of fish is:

(2 l) × + (0.0187 × F) × =ADI

where

2 l=2 liters of drinking water
0.0187 kg=amount of fish consumed daily
F=bioconcentration factor (130 for 2,4,5-trichlorophenol)
ADI=Allowable Daily Intake (mg/day for a 70 kg person)

(2 l) × + (0.0187 × 130) × =7.0 mg
2 × + 2.43 × =7.0
4.43 × =7.0
× =1.6 mg/l

There are no toxicity data for tetrachorophenol, but because of the similarities between tetra- and pentachlorophenol and the lower acute toxicity of tetrachlorophenol, it is reasonable to set the water criterion on the basis of the more extensive toxicologic data base for pentachlorophenol.

The criterion is established as follows. The no observable effect level (NOEL) for pentachlorophenol is 3 mg/kg. Since the chlorophenols are rapidly excreted by mammals, an uncertainty factor of 100 is used to establish the acceptable human exposure of 0.03 mg/kg per day. A water intake of 2 l/day and an average body weight of 70 kg are assumed. The acceptable whole body exposure is then 70 kg times 0.03 mg/kg/day which equals 2.1 mg/day.

Assuming that the total exposure is from ingesting 2 liters of drinking water and 18.7 grams of fish, the following calculation has been established:

(2 l) × + (0.0187 × BCF)=ADI

where

2 l=amount of drinking water consumed
0.0187 hg=amount of fish consumed
BCF=bioconcentration factor (320 for tetrachlorophenol)
ADI=Acceptable Daily Intake (2.1 mg)

In tetrachlorophenol, which is based on the use of chronic toxicologic data and an uncertainty factor of 100, the recommended criterion level is 263 µg/l. Drinking water contributes 25 percent of the assumed exposure while eating contaminated fish products accounts for 75 percent. The criterion level can alternatively be expressed as 351 if exposure is assumed to be from the consumption of fish and shellfish products alone.

The organoleptic properties of the chlorinated phenols are well known. These compounds have been reported to impart a medicinal-like odor and taste to water and to the flesh of aquatic organisms raised in contaminated water. Summaries of the reported taste/odor threshold levels of various chlorophenols in water or in aquatic organisms are presented in Table 1 and Table 2, respectively.

Water quality criteria for 2-chlorophenol and 2,4-dichlorophenol based on organoleptic effects were published in FR 15946, 1979. These criteria of 0.3 µg/l and 0.5 µg/l, respectively, were derived from the data reported by Hoak (1957) and are based on the odor threshold of these compounds in water.

The criteria for various other mono-, di-, and trichlorophenols have been derived and are based on the lower of the odor threshold in water or the trainting threshold in aquatic organisms (see Table 3).

Since the criterion derived for tetrachlorophenol based on its toxic effects is lower than that derived as a result of its organoleptic properties, the former criterion is recommended.

There are no available data on monochlorocresols upon which to base a criterion.

Table 1.—*Comparison of Odor Thresholds for Chlorophenols in Water*

	Threshold-ppb (µg/l)	Reference[a]
2-chlorophenol	0.33 ppb – 30°	2
	2 ppb – 25°	3
	6 ppb – NS[b]	4
3-chlorophenol	200 ppb – 30°C	2
4-chlorophenol	33 ppb – 30°C	2
	250 ppb – 25°C	3
	900 – 1350 ppb	4
2,4-dichlorophenol	0.65 ppb – 30°C	2
	2 ppb – 25°C	3
2,5-dichlorophenol	3.3 ppb – 30°C	2
2,6-dichlorophenol	3 ppb – 25°C	3
2,4,5-trichlorophenol	11 ppb – 25°C	2
2,4,6-trichlorophenol	100 ppb – 30°C	2
	1000 ppb – 25°C	3
2,3,4,6-tetrachlorophenol	915 ppb – 30°C	2

[a] 2—Hoak, 1957; 3—Burttschell, et al., 1959; 4—Campbell, et al., 1958.
[b] NS—temperature not specified.

Table 2.—*Summary of Threshold Concentrations of Chlorinated Phenols in Water That Cause Tainting of the Flesh of Aquatic Organisms*

Compound	Threshold (µg/l)	Reference[a]
2-chlorophenol	15.0	1
	15.0	2
3-chlorophenol	60.0	1
4-chlorophenol	60.0	1
	60.0	2
2,4-dichlorophenol	5.0	2
	10.0	3

[a] 1—Schulze, E., 1961; 2—Teal, J. L., 1959; 3—Chumney, D. L., 1966.

Table 3.—*Recommended Water Quality Criteria*

Compound	Criterion from organoleptic effects	Criterion from toxicological data
Monochlorophenols		
3-chlorophenol	50 µg/l	none
4-chlorophenol	30 µg/l	none
Dichlorophenols		
2,5-dichlorophenol	9.0 µg/l	none
2,6-dichlorophenol	9.0 µg/l	none
Trichlorophenols		
2,4,5-trichlorophenol	10 µg/l	1800 µg/l
2,4,6—trichlorophenol	100 µg/l	
Tetrachlorophenol*		
2,3,4,6-tetrachlorophenyl	900 µg/l	263 µg/l

*The criterion will be based on toxicological effects

Copper

Criteria Summary

Freshwater Aquatic Life. For copper the criterion to protect freshwater aquatic life as derived using the Guidelines is "ϵ(0.65 ln (hardness)−1.94)" as a 24-hour average and the concentration should not exceed "ϵ(0.88 ln (hardness)−1.03)" at any time.

Saltwater Aquatic Life. For copper the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.79 μg/l as a 24-hour average and the concentration should not exceed 18 μg/l at any time.

Human Health. For copper the criterion to protect human health is 1 mg/l.

Freshwater Aquatic Life. The maximum concentration of copper is the Final Acute Value of ϵ(0.88•ln (hardness)−1.03) and the 24-hour average concentration is the Final Chronic Value of ϵ(0.65•ln (hardness)−1.94). No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

Summary of Available Data. All concentrations herein are expressed in terms of copper.

Final Fish Acute Value = ϵ(0.72•ln (hardness)+0.83)
Final Invertebrate Acute Value = ϵ(0.88•ln hardness)−1.03
Final Acute Value = ϵ(0.88•ln (hardness)−1.03)
Final Fish Chronic Value = ϵ(0.65•ln (hardness)−1.94)
Final Invetebrate Chronic Value = ϵ(0.65•ln (hardness)−1.42)
Final Plant Value = 1 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = ϵ(0.65•ln (hardness)−1.94)

Saltwater Aquatic Life. The maximum concentration of copper is the Final Acute Value of 1.8 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

Summary of Available Data. The concentrations below have been rounded to two significant figures. All concentrations herein are expressed in terms of copper.

Final Fish Acute Value = 19 μg/l
Final Invertebrate Acute Value = 1.8 μg/l
Final Acute Value = 1.8 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = 11 μg/l
Final Plant Value = 5.0 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 5.0 μg/l
0.44 × Final Acute Value = 0.79 μg/l

Human Health. Copper is an essential dietary element for humans and animals. A level of 2 mg per day will maintain adults in balance and has been considered adequate, although because of interactions with other dietary constituents which limit absorption and utilization, a requirement level must be considered in conjunction with such constituents as zinc, iron, fiber, and ascorbic acid. The minimum level meeting requirements for copper intake in intravenous feeding was 22 μg copper/kg body weight.

The short biological half life of copper and the homeostasis that exists in humans prevents copper from accumulating, even with dietary intakes considerably in excess of 2 mg per day. In the opinion of many investigators, there is much more likelihood of a copper deficiency occurring than of a toxicity developing with current dietary and environmental situations.

Although acute and chronic levels of intake may occur, there are no good data which define these levels. It has been suggested that chronic intakes of 15 mg of copper per day may produce observable effects, but if zinc and iron intakes are also increased, much higher levels may be consumed without adverse reactions. The data for acute toxicity are even more uncertain, since practically all human information stems from cases of attempted suicide.

The available literature leads to the conclusion that copper does not produce teratogenic, mutagenic, or carcinogenic effects. The limited information available indicates that where such action has occurred, e.g., with mixtures of copper sulfate and lime, arsenic, or enediols, the copper should be considered as interacting with the other materials and not as the active material.

The current drinking water standard of 1 mg/l is considered to be well below any minimum hazard level, even for special groups at risk such as very young children, and therefore it is recommended that this standard be maintained.

Cyanide

Criteria Summary

Freshwater Aquatic Life. For free cyanide (expressed as CN) the criterion to protect freshwater aquatic life as derived using the Guidelines is 1.4 μg/l as a 24-hour average and the concentration should not exceed 38 μg/l at any time.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for free cyanide can be derived using the Guidelines, and there are insufficient data to estimate a cirterion using other procedures.

Human Health. For cyanide, the criterion to protect human health from the toxic properties of cyanide ingested through water and through contaminated aquatic organisms is 0.2 mg CN^-/l.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of free cyanide is the Final Acute Value of 38 μg/l and the 24-hour concentration is the Final Chronic Value of 1.4 μg/l. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For free cyanide (expressed as CN) the criterion to protect freshwater aquatic life as derived using the Guidelines is 1.4 μg/l as a 24-hour average and the concentration should not exceed 38 μg/l at any time.

Summary of Available Data. All concentrations herein are for free cyanide expressed as CN. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 38 μg/l
Final Invertebrate Acute Value = 60 μg/l
Final Acute Value = 38 μg/l
Final Fish Chronic Value = 1.4 μg/l
Final Invertebrate Chronic Value = 4.9 μg/l
Final Plant Value = 7,790 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 1.4 μg/l
0.44 × Final Acute Value = 17 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for free cyanide using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data. All values are for free cyanide expressed as CN. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = not available
Final Invertebrate Acute Value = not available
Final Acute Value = not available
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 3,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 3,000 μg/l
0.44 × Final Acute Value = not available

Table 1.—*Basis and Derivation of Cyanide Criterion*

Exposure levels [a]	Route	Species	Calculated daily exposure	Margin of safety [d]	Investigator
9.2 mg/m³	Inhalation	Man	60.8 mg [b]	152	El Ghawabi, et. al. 1975. [1]
2.5 mg/m³	Inhalation	Man	16.5 mg [b]	41	DHEW, PHS, 1976. [3]
12 mg/kg	Oral	Rat	840 mg [c]	20.8	Howard and Hanzal, 1955. [2]

[a] NOAEL.
[b] Based on 100% retention and on alveolar exchange of 6.6m³ for 8 hours.
[c] Rat data converted to human equivalent assuming food consumption of 60 g/kg for rats and 70 kg human.
[d] Daily exposure compared with 0.4 mg/day exposure from the consumption of 2 l water containing 0.2 mg/l.
[1] El Ghawabi, S. H., et al. 1975. Chronic cyanide exposure: a clincial, radioisotope, and laboratory study. Br. J. Ind. Med. 32:215.
[2] Howard, J. W., and R. F. Hanzal. 1955. Chronic toxicity for rats of food treated with hydrogen cyanide. J. Agr. Food Chem. 3:325.
[3] DHEW, PHS, 1976. Center for Disease Control, National Institute for Occupational Safety and Health, NIOSH Criteria for Recommended Standard Occupational Exposure to Hydrogen Cyanide and Cyanide Salts (NaCN, KCN, and $Ca(CN)_2$). DHEW, NIOSH Publ. No. 77-108. U.S. Government Printing Office, Washington, D.C.

Human Health. As shown in Table 1, the criterion of 0.2 mg CN^-/l allows for safety factors ranging from 41 to 2100. El Ghawabi, et al. (1975)[1] studied the effects of chronic cyanide exposure in the electroplating sections of three Egyptian factories. A total of 36 male employees with exposures up to 15 years were studied and compared with a control group of 20 normal, non-smoking males. Only minimal differences with respect to thyroid gland size and function were found. The El Ghawabi study was given considerable weight in formulating the NIOSH [3] recommendations for occupational exposure which gives a safety factor of 41 when applied to drinking water by the usual extrapolations (Table 1). Finally, a safety factor of 2,100 is obtained using the results of a two year chronic feeding study in rats. When fed at the rate of 12 mg/kg per day over the equivalent of a lifetime, these rats showed no overt signs of cyanide poisoning, and hematological values were normal. Gross and microscopic examinations of tissues revealed no abnormalities. The only abnormality found was an elevation of thiocyanate levels in the liver and kidneys. Consequently the ADI for man is derived by taking the no observable adverse effect level in mammals (12 mg/kg/day) multiplied by the weight of the average man (70 kg) and dividing by a safety factor of 100. Thus;

$$ADI = 12\ mg/kg/day \times 70\ kg \div 100 = 8.4\ mg/day.$$

The equation for calculating the criterion for the cyanide content of water given an Acceptable Daily Intake is

$$2X + [(0.0187)(F)(X)] = ADI$$

Where

2 = amount of drinking water, l/day
X = cyanide concentration in water, mg/l
0.0187 = amount of fish consumed, kg/day
F = bioconcentration factor, mg cyanide/kg fish per mg cyanide/l water
ADI = limit on daily exposure for a 70 kg person = 8.4 mg/day

$2X + (0.0187)(2.3)X = 8.4$
$X = 4.16$ mg/l

Thus, the current and recommended criteria (0.2 mg/l) has a margin of safety of 20.8 (4.16 ÷ 0.2).

No new additional evidence was encountered to suggest that the 1962 PHS Drinking Water Standard for cyanide should be lowered. The concentration of 0.2 mg/l or less is easily achieved by proper treatment and concentrations in excess of that amount have been encountered only on rare occasions in U.S. water supplies. The experience since 1962 suggests that 0.2 mg CN^-/l is a safe criterion not only for man but for most species of fish as well. Although cyanide has been implicated in fish kills, these represent isolated, accidental and localized cases of pollution where the cyanide concentrations must have been greatly in excess of the P.H.S. limit.

Cyanide is unlikely to become a widespread environmental pollutant because of its low degree of persistence in the biosphere. It is not accumulated or stored in mammals and there is no evidence for its biomagnification in food chains. Well controlled attempts to show cumulative toxic effects have not been successful. No data exist to suggest that cyanide produces such irreversible effects as mutagenesis, teratogenesis or cancer.

3,3'-Dichlorobenzidine (DCB)

Criteria Summary

Freshwater Aquatic Life. For freshwater aquatic life, no criterion for any dichlorobenzidine can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for any dichlorobenzidine can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. For the maximum protection of human health from the potential carcinogenic effects of exposure to dichlorobenzidine through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of toxaphene estimated to result in additional lifetime cancer risks ranging from no additional risk to an additional risk of 1 in 100,000 are presented in the Criterion Formulation section of this document. The Agency is considering setting criteria at an interim target risk level in the range of 10^{-5}, 10^{-6}, or 10^{-7} with corresponding criteria of 0.1 μg/l, 0.01 μg/l and 0.001 μg/l respectively.

Basis for the Criteria

Freshwater Aquatic Life. No freshwater criterion can be derived for dichlorobenzidine using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Saltwater Aquatic Life. No saltwater criterion can be derived for dichlorobenzidine using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Human Health. The water quality criterion for DCB is based on the induction of papillary transitional cell carcinomas of the urinary bladder and hepatic carcinomas in female beagle dogs, given an oral dose of 100 mg 3,3'-dichlorobenzidine, three times per week for six weeks, then five times per week continuously for up to 7.1 years (Stula, et al. 1978).[1] Dose-response data for dogs were selected because dogs developed urinary bladder tumors, as do humans, when exposed to certain aromatic amines. The concentration of DCB in water, calculated to keep the lifetime cancer risk below 10^{-5}, is 0.10 μg/l.

Under the Consent Decree in *NRDC vs. Train*, criteria are to state "recommended maximum permissible concentrations (including where

[3] DHEW, PHS. 1976. Center for Disease Control, National Institute for Occupational Safety and Health, NIOSH Criteria for Recommended Standard Occupational Exposure to Hydrogen Cyanide and Cyanide Salts (NaCN, KCN and $Ca(CN)_2$). DHEW, NIOSH Publ. No. 77-108, U.S. Gov. Printing Office, Washington, D.C.

[1] Stula, E. F., J. R. Barnes, H. Sherman, C. F. Reinhardt, J. A. Zapp, Jr. 1978, J. Environmental Pathology and Toxicology, 1: 475-490.

appropriate, zero) consistent with the protection of aquatic organisms, human health, and recreational activities." DCB is suspected of being a human carcinogen. Because there is no recognized safe concentration for a human carcinogen, the recommended concentration of DCB in water for maximum protection of human health is zero.

Because attaining a zero concentration level may be infeasible in some cases and in order to assist the Agency and States in the possible future development of water quality regulations, the concentrations of DCB corresponding to several incremental lifetime cancer risk levels have been estimated. A cancer risk level provides an estimate of the additional incidence of cancer that may be expected in an exposed population. A risk of 10^{-5} for example, indicates a probability of one additional case of cancer for every 100,000 people exposed, a risk of 10^{-6} indicates one additional case of cancer for every million people exposed, and so forth.

In the **Federal Register** notice of availability of draft ambient water quality criteria, EPA stated that it is considering setting criteria at an interim target risk level of 10^{-5}, 10^{-6} or 10^{-7} as shown in the table below.

Exposure assumptions	Risk levels and corresponding criteria[1]			
	0	10^{-7}	10^{-6}	10^{-5}
2 liters of drinking water and consumption of 18.7 grams fish and shellfish[2].	0	0.001 μg/l	0.01 μg/l	0.1 μg/l
Consumption of fish, shellfish only	0	0.002 μg/l	0.02 μg/l	0.2 μg/l

[1]Calculated by applying a modified "one hit" extrapolation model described in the FR 15926, 1979. Since the extrapolation model is linear to low doses, the additional lifetime risk is directly proportional to the water concentration. Therefore, water concentrations corresponding to other risk levels can be derived by multiplying or dividing one of the risk levels and corresponding water concentrations shown in the table by factors such as 10, 100, 1,000, and so forth.

[2]Forty-eight percent of DCB exposure results from the consumption of aquatic organisms which exhibit an average bioconcentration potential of 100 fold. The remaining 52 percent of DCB exposure results from drinking water.

Concentration levels were derived assuming a lifetime exposure to various amounts of DCB, (1) occurring from the consumption of both drinking water and aquatic life grown in water containing the corresponding DCB concentrations and, (2) occurring solely from consumption of aquatic life grown in the waters containing the corresponding DCB concentrations.

Although total exposure information for DCB is discussed and an estimate of the contributions from other sources of exposure can be made, this data will not be factored into the ambient water quality criteria formulation because of the tenuous estimates. The criteria presented, therefore, assume an incremental risk from ambient water exposure only.

Summary of Pertinent Data. The water quality criterion for DCB is based on the induction of papillary transitional cell carcinomas of the urinary bladder and hepatic carcinomas in female beagle dogs, given an oral dose of 100 mg DCB, three times per week for six weeks, then five times per week continuously for periods up to 7.1 years (Stula, et al. 1978).[1] The incidence of urinary bladder carcinomas observed in DCB-treated dogs was 5/5 as compared to 0/6 in the control group. The incidences of hepatic carcinomas were 4/5 and 0/6 in DCB-treated and control groups, respectively. The criterion was calculated from the following parameters.

$n_{tu} = 4.5^*$ (urinary bladder carcinomas)
$N_{tu} = 5$
$n_{th} = 4$ (hepatic carcinoma)
$N_{th} = 5$
$n_c = 0$
$N_c = 6$
$Le = 7.1$ yrs.
$le = 7.1$ yrs.
$L = 8.65$ yrs.
d (timeweighted average concentration) = 7.36 mg/kg/day
$F = 0.0187$ kg
$R = 100$
$W = 11.391$ kg

Based on these parameters, the one-hit slope (B_H) is 1.036 $(mg/kg/day)^{-1}$ for urinary bladder carcinomas and 0.724 $(mg/kg/day)^{-1}$ for hepatic carcinomas. The resulting water concentration for DCB, calculated to keep the individual lifetime cancer risk below 10^{-5}, is 0.10 micrograms per liter.

Dichloropropanes/Dichloropropenes

Criteria Summary

Freshwater Aquatic Life. For 1,1-dichloropropane the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 410 μg/l as a 24-hour average and the concentration should not exceed 930 μg/l at any time.

For 1,2-dichloropropane the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 920 μg/l as a 24-hour average and the concentration should not exceed 2,100 μg/l at any time.

For 1,3-dichloropropane the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 4,800 μg/l as a 24-hour average and the concentration should not exceed 11,000 μg/l at any time.

For 1,3-dichloropropene the criterion to protect freshwater aquatic life as derived using the Guidelines is 18 μg/l as a 24-hour average and the concentration should not exceed 250 μg/ l at any time.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for 1,1-dichloropropane can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

For 1,2-dichloropropane the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 400 μg/l as a 24-hour average and the concentration should not exceed 910 μg/l at any time.

For 1,3-dichloropropane the criterion to protect saltwater aquatic life as derived using the Guidelines is 79 μg/l as a 24-hour average and the concentration should not exceed 180 μg/ l at any time.

For 1,3-dichloropropene the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 5.5 μg/l as a 24-hour average and the concentration should not exceed 14 μg/l at any time.

Human Health. For the protection of human health from the adverse effects of dichloropropanes and dichloropropenes ingested through the consumption of contaminated fish and water, the following criteria are suggested:

Dichloropropanes—200 μg/l
Dichloropropenes—0.63 μg/l

Basis for the Criteria

Freshwater Aquatic Life. No freshwater criterion can be derived for any dichloropropane using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available.

However, data for 1,3-dichloropropane and saltwater

*This underestimate of the true number, based on Burkson's correction factor, was chosen in order to obtain a finite mathematical estimate.

organisms can be used as the basis for estimating criteria.

For 1,3-dichloropropane and saltwater organisms, 0.44 times the Final Acute Value is less than the Final Chronic Value derived from a life cycle test with the mysid shrimp. Therefore, a reasonable estimate of criteria for dichloropropanes and freshwater organisms would be 0.44 times the Final Acute Value. The lack of a Final Fish Acute Value for 1,3-dichloropropane and freshwater fish is probably not important since the Final Fish Acute Value is greater than the Final Invertebrate Acute Value for all three cases with freshwater and saltwater organisms in which both values are available.

1,1-dichloropropane

The maximum concentration of 1,1-dichloropropane is the Final Acute Value of 930 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the estimated 24-hour average concentration.

For 1,1-dichloropropane the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 410 μg/l as a 24-hour average and the concentration should not exceed 930 μg/l at any time.

1,2-dichloropropane

The maximum concentration of 1,2-dichloropropane is the Final Acute Value of 2,100 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the estimated 24-hour average concentration.

For 1,2-dichloropropane the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 920 μg/l as a 24-hour average and the concentration should not exceed 2,100 μg/l at any time.

1,3-dichloropropane

The maximum concentration of 1,3-dichloropropane is the Final Acute Value of 11,000 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the estimated 24-hour average concentration.

For 1,3-dichloropropane the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 4,800 μg/l as a 24-hour average and the concentration should not exceed 11,000 μg/l at any time.

1,3-dichloropropene

The maximum concentration of 1,3-dichloropropene is the Final Acute Value of 250 μg/l and the 24-hour average concentration is the Final Chronic Value of 18 μg/l. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 1,3-dichloropropene the criterion to protect freshwater aquatic life as derived using the Guidelines is 18 μg/l as a 24-hour average and the concentration should not exceed 250 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

1,1-dichloropropane

Final Fish Acute Value = 14,000 μg/l
Final Invertebrate Acute Value = 930 μg/l
Final Acute Value = 930 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = not available
0.44 × Final Acute Value = 410 μg/l

1,2-dichloropropane

Final Fish Acute Value = 42,000 μg/l
Final Invertebrate Acute Value = 2,100 μg/l
Final Acute Value = 2,100 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = not available
0.44 × Final Acute Value = 920 μg/l

1,3-dichloropropane

Final Fish Acute Value = not available
Final Invertebrate Acute Value = 11,000 μg/l
Final Acute Value = 11,000 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 48,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 48,000 μg/l
0.44 × Final Acute Value = 4,800 μg/l

1,3-dichloropropene

Final Fish Acute Value = 850 μg/l
Final Invertebrate Acute Value = 250 μg/l
Final Acute Value = 250 μg/l
Final Fish Chronic Value = 18 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 5,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 18 μg/l
0.44 × Final Acute Value = 110 μg/l

Saltwater Aquatic Life. The maximum concentration of 1,3-dichloropropane is the Final Acute Value of 180 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 1,3-dichloropropane and saltwater organisms the Final Invertebrate Acute Value divided by the Final Fish Acute Value is 180 μg/l/13,000 μg/l = 0.014. The comparable quotient for 1,2-dichloropropane and freshwater organisms is 2,100 μg/l/57,000 μg/ l=0.037. The average quotient is 0.026. Multiplying this value times the Final Acute Value for 1,2-dichloropropane and saltwater fish results in an estimated Final Invertebrate Acute Value of 0.026 × 35,000 μg/l = 910 μg/l. Thus the estimated Final Acute Value for 1,2-dichloropropane is 910 μg/l. Multiplying this Final Acute Value by 0.44 gives 400 μg/l.

For 1,3-dichloropropane and saltwater organisms, 0.44 times the Final Acute Value is less than the Final Chronic Value derived from a life cycle test with the mysid shrimp. Therefore, a reasonable estimate of a criterion for 1,2-dichloropropane and saltwater organisms would be 0.44 times the Final Acute Value.

The maximum estimated concentration of 1,2–dichloropropane is the Final Acute Value of 910 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the estimated 24-hour average concentration.

For 1,3-dichloropropene and freshwater fish the Final Chronic Value divided by the Final Acute Value is 18 μg/l/850 μg/l = 0.021. Multiplying this value times the Final Acute Value for 1,3-dichloropropene and saltwater fish results in an estimated Final Fish Chronic Value of 0.021 × 260 μg/l = 5.5 μg/l. Thus the estimated Final Chronic Value is 5.5 μg/l and is slightly lower than 0.44 times the Final Acute Value.

The maximum concentration of 1,3-dichloropropene is the Final Acute Value of 14 μg/l and the estimated 24-hour average concentration is the Final Chronic Value of 5.5 μg/l. No important adverse effects on saltwater aquatic organisms have been reported to be

caused by concentrations lower than the estimated 24-hour average concentrations.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

1,2-dichloropropane

Final Fish Acute Value = 35,000 μg/l
Final Invertebrate Acute Value = not available
Final Acute Value = 35,000 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant Concentration = not available
Final Chronic Value = not available
0.44 × Final Acute Value = 15,000 μg/l

1,3-dichloropropane

Final Fish Acute Value = 13,000 μg/l
Final Invertebrate Acute Value = 180 μg/l
Final Acute Value = 180 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = 600 μg/l
Final Plant Value = 66,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 600 μg/l
0.44 × Final Acute Value = 79 μg/l

1,3-dichloropropene

Final Fish Acute Value = 280 μg/l
Final Invertebrate Acute Value = 14 μg/l
Final Acute Value = 14 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 1,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 1,000 μg/l
0.44 × Final Acute Value = 6.2 μg/l

Human Health. The Ostwald coefficient () is defined as the ratio of the concentration of a gas in a liquid to the concentration of the gas in an equivalent volume of gas above that liquid. By definition, the Ostwald coefficient of a gas and water at any particular temperature could be expressed:

$$= \frac{\text{water solubility (g/l/)}}{\text{conc. or vapor (g/l) at a partial pressure equal to vapor pressure}}$$

In the criteria formulation, the Ostwald coefficient for water is used as that for blood. A review of data on volatile anesthetic agents indicated this approach was acceptable. The applicability of this procedure can be used to estimate X_b.

The determined blood concentrations of PDC in rabbits and dogs after a seven-hour exposure period are from exposure data, blood levels that are calculated based on the Ostwald coefficient determined here (see below), and a hematocrit of 0.50. The data are as follows:

Animal	Exposure conc. (mg/l)	Blood conc. found (mg/l)	Blood conc. calculated (mg/l)
Rabbits	10.3	15–20	26.5
Rabbits	6.0	6–11	16.7
Dogs	4.7	13–16	13.0

Dichloropropane

It was determined that vapor pressure P (20° C) = 40 mm Hg and P (38° C) = 90 mm Hg. Unfortunately the only solubility data available was that for 20° C. However, data available on trichloroethylene and chloroform indicated that

$$\frac{P_{17^\circ}}{P_{20}} = 0.512$$

A similar relationship was found for ether. This factor was utilized for PDC:

Solubility in water = 2.7 g/l

$$\text{Concentration in air} = n/v = \frac{P}{RT} = \frac{40}{62 \times 293} =$$

$$0.0022 \text{ mole/l} = 0.25 \text{ g/l}$$

$$20^\circ = \frac{2.7}{0.25} = 10.8$$

$$38^\circ = 10.8 \times 0.512 = 5.5$$

Dichloropropene

A valid vapor pressure value for DCP could not be identified as such.

Therefore, the vapor in air density of DCP (cis and trans) of 1.4 at 37.8° C is used. Vapor air density (D) can be expressed as:

$$D = \frac{Pd}{P'} + \frac{P'-P}{P'}$$

where P = vapor pressure (at 37.8°)
P' = ambient pressure (760 mm Hg)
d = vapor density (3.8 for DCP)

Therefore

$$P = \frac{P'D-P}{d-1} = 109 \text{ mm Hg}$$

This is a feasible relationship to the vapor pressure of 90 mm Hg at 38° C reported for PDC. An assumption of parallelism for plots of log vapor pressure vs. 1/T for PDC and DCP is reasonable. Thus the vapor pressure of DCP at 20° C can be assumed to be 59 mm Hg. This conversion is necessary since the only available solubility data for DCP is at 20°.

Thus

$$n/v = \frac{P}{RT} = \frac{59}{62 \times 293} = 0.0032 \text{ moles/l}$$
$$= 0.36 \text{ g/l}$$

solubility of DCP in water at 20° = 1.0 g/l

$$20^\circ = \frac{1.0 \text{ g/l}}{0.36 \text{ g/l}} = 2.8$$

$$38^\circ = 2.8 \times 0.512 = 1.4$$

D–D [R], in one study was found to have a vapor pressure of 35 mm Hg at 20°; in another it was found to have a vapor pressure of 31.3 mm Hg at 20° C.

If these values are accurate, then the mixture of PDC and DCP can be assumed to be a negative deviation from Raoult's law. Measurements of partial pressure of binary solutions show that most of them can be classified as deviating from Raoult's law, either positively or negatively. The implication of this behavior of mixtures of PDC and

DCP has been discussed in this document as regards the interpretation of mutagenicity data.

The derivation of k is the most speculative portion of the model. From the data presented earlier, it can be assumed that the rat excretes 80 percent of a dose in 24 hours. It is likely, however, that PDC and DCP fit a two compartment pharmacokinetic model, at the least. Only the first (water) compartment in the rat can be reasonably estimated from the data available. Based on differences in glomerular filtration rate/weight relationships between rat and man, the k of a rat was reduced from 0.80×24 hr^{-1} to 0.25×24 hr^{-1}. This is a moderate estimate which should also allow for known higher rates of biotransformation in the rat when compared to man.

The volume of distribution (V_D) of the compounds was assumed to be in a total body water plus fat:

Thus
$V_D = V_{TBW} + (V_F \times {}_{W/F})$
where
V_{TBW} = volume of total body water (36L in 70 kg man)
V_F = volume of fat (10 l in 70 kg man)
${}_{W/F} = {}_{O/W}$ = blood/water partition coefficient (taken as octanol/water partition coefficient).

A major consideration is the time necessary for the blood to reach equilibrium with the fat. Because this process is slow, the possibility exists for significant elevation of X_b, if V_D as calculated above is used.

To account for this, it was recognized that the NOAEL inhalation exposures were based on seven to eight hours of exposure. Consequently, a safety factor was incorporated in the V_D calculation such that the lipid space was corrected to include only that apparent fat volume which would be filled during 8 hours to exposure.

Thus
$V^D = V_{TBW} + (V_F \times {}_{O/W} \times F_{8h})$
where
F_{8h} = fraction of final equilibrium level of substance fat after 8 hours.
$F_{8h} = 1 - e^{-kt}$
$\ln(1-F) = -kt$
where
k =

plasma flow rate per minute in fat (0.11)

V_F O/W
t = 480 minutes

Dichloropropane

${}_{O/W} = 105$
$F_{8h} = 0.05$
$V_D = 36 + (10 \times 105 \times 0.05) = 89$

Dichloropropene

${}_{O/W} = 43$
$F_{8h} = 0.11$
$V_D = 36 + (10 \times 43 \times 0.11) = 83$

Criteria

As stated above:

$$ADI = \frac{\text{Ingestion NOAEL}}{\text{Uncertainty factor}}$$

The uncertainty factor for both PDC and DCP was taken as 100 based on the fact that the inhalation data utilized appears highly reliable and conversions to ingestion NOAEL have built in underestimation factors.

Finally:

$$CR = \frac{ADI}{2 + (BCF \times 0.0187)}$$

where
CR = water quality criterion
2 = liters of water consumed per day
BCF = bioconcentration faction in edible portion fish (obtained from USEPA Duluth Laboratory)
0.0187 = estimated consumption (kg) by an individual daily

Dichloropropane

The inhalation NOAEL for PDC is 75 ppm (350 mg/m³) which is the ACGIH TLV
$\lambda = 5.5$
$X_a = 0.35$ mg/l
$X_b = 5.5 \times 0.35 = 1.9$ mg/l
$V_D = 89$ l
$k = 0.25 \times 24$ hr^{-1}

$$ADI = \frac{0.25 \times 1.9 \times 89}{100} = 420\ \mu g/day$$

$BCF = 5.8$

$$CR = \frac{420}{2 + (5.8 \times 0.0187)} = 200\ \mu g/l$$

Dichloropropene

The inhalation NOAEL for DCP is 1 ppm (4.5 mg/m³) which is that recommended by Torkelson and Oyen (1977).[1]
$\lambda = 1.4$
$X_a = 4.5$
$X_b = 1.4 \times 4.5 = 6.3$ µg/l
$V^D = 83$
$k = 0.25 \times 24$ hr^{-1}

$$ADI = \frac{0.25 \times 6.3 \times 83}{100} = 1.3\ \mu g/day$$

$BCF = 2.9$

$$CR = \frac{1.3\ \mu g}{2 + (2.9 \times 0.0187)} = 0.63\ \mu g/l$$

In summary, based upon the use of an inhalation no-observed-adverse-effect-level in rats (DCP), and an uncertainty factor of 100, the criterion level corresponding to the estimated acceptable daily intake of 1.3 µg/day for DCP and 420 µg/day for PDC is .6 µg/l and 200 µg/l, respectively. Drinking water accounts for 95 percent of the assumed exposure for PDC and 98 percent for DCP. The criterion level can alternatively be expressed as 3.9 mg/l for PDC and 24 µg/l for DCP if exposure is assumed to be from the consumption of fish and shellfish products alone.

These criterion formulations assure that 100% of man's exposure is assigned to the ambient water pathway as information on other likely exposure situations is unavailable.

Dinitrotoluenes

Criteria Summary

Freshwater Aquatic Life. For 2,3-dinitrotoluene the criterion to protect freshwater aquatic life as derived using the Guidelines is 12 µg/l as a 24-hour average and the concentration should not exceed 27 µg/l at any time.

For 2,4-dinitrotoluene the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 620 µg/l as a 24-hour average and the concentration should not exceed 1,400 µg/l at any time.

Saltwater Aquatic Life. For 2,3-dinitrotoluene the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 4.4 µg/l as a 24-hour average and the concentration should not exceed 10 µg/l at any time.

For saltwater aquatic life, no criterion for 2,4-dinitrotoluene can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. For the maximum protection of human health from the potential carcinogenic effects of exposure to 2,4-dinitrotoluene through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of 2,4-dinitrotoluene estimated to result in additional lifetime cancer risks ranging from no additional risk to an additional risk of 1 in 100,000 are presented in the Criterion Document. The Agency is considering setting criteria at an interim target risk level in the range of 10^{-5}, 10^{-6}, or 10^{-7} with corresponding criteria of 740 ng/l, 74.0 ng/l, and 7.4 ng/l, respectively.

Basis for the Criteria

Freshwater Aquatic Life—2,3-dinitrotoluene. The maximum concentration of 2,3-dinitrotoluene is the Final Acute Value of 27 µg/l and the 24-hour average concentration is 0.44 times

[1] Torkelson, R. R., and F. Oyen. 1977. The toxicity of 1,3-dichloropropene as determined by repeated exposure of laboratory animals. Jour. Am. Ind. Hyg. Assoc. 38: 217.

the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 2,3-dinitrotoluene the criterion to protect freshwater aquatic life as derived using the Guidelines is 12 μg/l as a 24-hour average and the concentration should not exceed 27 μg/l at any time.

2, 4-dinitrotoluene. Results obtained with 2,3-dinitrotoluene and freshwater organisms indicate how a criterion may be estimated for 2,4-dinitrotoluene and freshwater organisms.

For 2,3-dinitrotoluene and freshwater organisms 0.44 times the Final Acute Value is less than the Final Chronic Value based on an embryo-larval test with the fathead minnow. Therefore, a reasonable estimate of a criterion for 2,4-dinitrotoluene and freshwater organisms would be 0.44 times the Final Acute Value.

The maximum concentration of 2,4-dinitrotoluene is the Final Acute Value of 1,400 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 2,4-dinitrotoluene the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 620 μg/l as a 24-hour average and the concentration should not exceed 1,400 μg/l at any time.

Summary of Available Data

The concentrations below have been rounded to two significant figures.

2,3-dinitrotoluene

Final Fish Acute Value=46 μg/l
Final Invertebrate Acute Value=27 μg/l
Final Acute Value=27 μg/l
Final Fish Chronic Value=17 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 1,400 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 17 μg/l
0.44 x Final Acute Value = 12 μg/l

2,4-dinitrotoluene

Final Fish Acute Value = 4,300 μg/l
Final Invertebrate Acute Value = 1,400 μg/l
Final Acute Value = 1,400 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant Concentration = not available
Final Chronic Value = not available
0.44 x Final Acute Value = 620 μg/l

Saltwater Aquatic Life

Results obtained with 2,3-dinitrotoluene and freshwater organisms indicate how a criterion may be estimated for 2,4-dinitroluene and saltwater organisms.

For 2,3-dinitrotoluene and freshwater organisms 0.44 times the Final Acute Value is less than the Final Chronic Value based on an embryo-larval test with the fathead minnow. Therefore, a reasonable estimate of the criterion for 2,3-dinitrotoluene and saltwater organisms would be 0.44 times the Final Acute Value.

The maximum concentration of 2,3-dinitrotoluene is the Final Acute Value of 10 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 2,3-dinitrotoluene the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 4.4 μg/l as a 24-hour average and the concentration should not exceed 10 μg/l at any time.

Summary of Available Data

The concentrations below have been rounded to two significant figures.

2,3-dinitrotoluene

Final Fish Acute Value = 340 μg/l
Final Invertebrate Acute Value = 10 μg/l
Final Acute Value = 10 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 370 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 370 μg/l
0.44 x Final Acute Value = 4.4 μg/l

Human Health. The data from the bioassay of 2,4-DNT for possible carcinogenicity obtained by the National Cancer Institute (NCI, 1978 [1] and Lee, et al. 1978 [2]) were used for the determination of a water quality criterion for the protection of human health. The criterion was developed from the animal carcinogenicity data utilizing a linear non-threshold model.

The rat carcinogenicity studies with dietary administration of 2,4-DNT showed increased incidences of fibroadenomas of the subcutaneous tissue and inanition in male rats and fibroadenomas of the mammary gland and inanition in female rats.

Under the Consent Decree in *NRDC vs Train,* criteria are to state "recommended maximum permissible concentrations (including where appropriate, zero) consistent with the protection of aquatic organisms, human health, and recreational activities." 2,4-DNT is suspected of being a human carcinogen. Because there is no recognized safe concentration for a human carcinogen, the recommended concentration of 2,4-DNT in water for maximum protection of human health is zero.

Because attaining a zero concentration level may be infeasible in some cases and in order to assist the Agency and States in the possible future development of water quality regulations, the concentrations of 2,4-DNT corresponding to several incremental lifetime cancer risk levels have been estimated. A cancer risk level provides an estimate of the additional incidence of cancer that may be expected in an exposed population. A risk of 10^{-5} for example, indicates a probability of one additional case of cancer for every 100,000 people exposed, a risk of 10^{-6} indicates one additional case of cancer for every million people exposed, and so forth.

In the **Federal Register** notice of availability of draft ambient water quality criteria, EPA stated that it is considering setting criteria at an interim target risk level of 10^{-5}, 10^{-6} or 10^{-7} as shown in the table below.

[1] NCI. 1978. Bioassay of 2,4-dinitrotoluene for possible carcinogenicity. National Cancer Institute Carcinogenesis Technical Report Series No. 54. U.S.D.H.E.W. (NIH) Pub. No. 78-1360. U.S. Government Printing Office, Washington, D.C.

[2] Lee, C. C., et al. 1978. Mammalian toxicity of munition compounds. Phase III: Effects of life-time exposure. Part I: 2,4-Dinitrotoluene. U.S. Army Medical Research and Development Command Contract No. DAMD-17-74-C-4073. Report No. 7, September, 1978.

Exposure assumptions (per day)	Risk levels and corresponding criteria [1]		
	10^{-7}	10^{-6}	10^{-5}
2 liters of drinking water and consumption of 18.7 grams fish and shellfish. [2]	7.4 ng/l	74.0 ng/l	740 ng/l
Consumption of fish and shellfish only	.156 μg/l	1.56 μg/l	15.6 μg/l

[1] Calculated by applying a modified "one-hit" extrapolation model described in the Methodology Document to the animal bioassay data presented in Appendix I and in Table 9. Since the extrapolation model is linear at low doses, the additional lifetime risk is directly proportional to the water concentration. Therefore, water concentrations corresponding to other risk levels can be derived by multiplying or dividing one of the risk levels and corresponding water concentrations shown in the table by factors such as 10, 100, 1000 and so forth.

[2] Approximately five percent of the DNT exposure results from the consumption of aquatic organisms which exhibit an average bioconcentration potential of 5.5 fold. The remaining 95 percent of DNT exposure results from drinking water.

Concentration levels were derived assuming a lifetime exposure to various amounts of DNT, (1) occurring from the consumption of both drinking water and aquatic life grown in waters containing the corresponding DNT concentrations and, (2) occurring solely from consumption of aquatic life grown in the waters containing the corresponding DNT concentrations. Although total exposure information for chloroform is discussed and an estimate of the contributions from other sources of exposure can be made, this data will not be factored into ambient water quality criteria. The criteria presented, therefore, assume an incremental risk from ambient water exposure only.

Summary of Pertinent Data

The water quality criterion for 2,4-dinitrotoluene is derived from the oncogenic effects observed in the mammary gland and liver of female Charles River CD rats fed 200 ppm in the diet. The time-weighted average dose of 45 mg/kg/day was given in the feed for 24 months, with the surviving animals sacrificed one month later. The mammary tumor incidence was 11/23 and 33/35 in the control and treated groups, respectively. The incidence of hepatocellular carcinomas and neoplastic nodules was 0/23 and 24/34 in the control and treated groups, respectively. Assuming a fish bioconcentration factor of 5.5, the criterion is calculated from the following parameters:

^{a}t mammary = 33
^{N}t mammary = 35
^{a}c mammary = 11
^{N}c mammary = 23
^{a}t liver = 24
^{N}t liver = 34
^{a}c liver = 0
^{N}c liver = 23
le = 24 months
Le = 25 months
d = 45 mg/kg/day
R = 5.5
L = 25 months
W = 0.464 kg
F = 0.0187 kg/day

Based on these parameters, the one-hit slope, ^{a}H, is 2.95×10^{-1} for mammary tumors and 1.53×10^{-1} for hepatocellular carcinomas and hepatocellular neoplastic nodules. The resulting water concentration of 2,4-dinitrotoluene calculated to keep the individual lifetime cancer risk below 10^{-5} is 740 ng/l.

Diphenylhydrazine

Criteria Summary

Freshwater Aquatic Life. For 1,2-diphenylhydrazine the criterion to protect freshwater aquatic life as derived using the Guidelines is 17 μg/l ad a 24-hour average and the concentration should not exceed 38 μg/l at any time.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for 1,2-diphenylhydrazine can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. For the maximum protection of human health from the potential carcinogenic effects of exposure to 1,2-diphenylhydrazine through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of 1,2-diphenylhydrazine estimated to result in additional lifetime cancer risks ranging from no additional risk to an additional risk of 1 in 100,000 are presented in the Criterion Formulation section of this document. The Agency is considering setting criteria at an interim target risk level in the range of 10^{-5}, 10^{-6}, or 10^{-7} with corresponding criteria of 0.4 μg/l, 0.04 μg/l and 0.004 μg/l, respectively.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of 1,2-diphenylhydrazine is the Final Acute Value of 38 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 1,2-diphenylhydrazine the criterion to protect freshwater aquatic life as derived using the Guidelines is 17 μg/l as a 24-hour average and the concentration should not exceed 38 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 38 μg/l
Final Invertebrate Acute Value = 170 μg/l
Final Acute Value = 38 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = 49 μg/l
Final Plant Value = not available
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 49 μg/l
0.44 × Final Acute Value = 17 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for 1,2-diphenylhydrazine using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Human Health. An evaluation of the subacute, acute and chronic toxicity, with the exception of carcinogenicity is impossible because of only scanty data. No current guidelines or standards presently exist for DPH.

Diphenylhydrazine has been shown to produce carcinogenic responses in rats and mice (NCI, 1974[1]; Pliss, 1974[2]). Since the NCI (1978[1])study represents the only report in which all the data can be analysed, it will be used as a basis for formulating a criterion.

More specifically, the data on the induction of cancer in male and female rats and female mice were chosen for analysis because they all had significantly increased tumor formation following DPH treatment (i.e. dietary). The respective criterion levels obtained from applying the standard water quality dose extrapolation/criteria calculation methodology are given in the following table.

1,2-Diphenylhydrazine Induction of Tumors in Mice and Rats[a]

Species	Sex	Estimated criterion level at 10^{-6} risk[b]
Mouse	Female	1.43 μg/l
Rat	Female	1.32 μg/l
		1.32 μg/l
	Male	5.14 μg/l
		0.38 μg/l

[a] Data taken from NCI, 1978.[1] (Tech No. 92, 1978).
[b] Calculated by applying a modified "one-hit" extrapolation model described in the Federal Register 1052–5, 1979.

It can be seen that male rats appear to have the lowest tolerance for DPH.

Under the Consent Decree in *NRDC vs. Train,* criteria are to state "recommended maximum permissible

[1] National Cancer Institute. 1978. Bioassay of hydrazobenzene for possible carcinogenicity. DHEW Publication No. (NIH) 78–1342.

[2] Pliss, G.B. 1974. Carcinogenic properties of hydrazobenzene. Vop. Onkol. 20: 53.

concentrations (including where appropriate, Zero) consistent with the protection of aquatic organisms, human health, and recreational activities." DPH is suspected of being a human carcinogen. Because there is no recognized safe concentration for human carcinogens the recommended concentration of DPH in water for maximum protection of human health is zero.

Because attaining a zero concentration level may be infeasible in some cases and in order to assist the Agency and States in the possible future development of water quality regulations, the concentrations of DPH corresponding to several incremental lifetime cancer risk levels have been estimated. A cancer risk level provides an estimate of the additional incidence of cancer that may be expected in an exposed population. A risk of 10^{-5} for example, indicates a probability of one additional case of cancer for every 100,000 people exposed, a risk of 10^{-6} indicates one additional case of cancer for every million people exposed, and so forth.

In the **Federal Register** notice of availability of draft ambient water quality criteria, EPA stated that it is considering setting criteria at an interim target risk level of 10^{-5}, 10^{-6} or 10^{-7} as shown in the table below.

Exposure assumptions	Risk levels and corresponding criteria [1]			
	0	10^{-7}	10^{-6}	10^{-5}
2 liters of drinking water and consumption of 18.7 grams fish and shellfish[2]	0	4 ng/l	40 ng/l	400 ng/l
Consumption of fish and shellfish only..	0	.019 μg/l	0.19 μg	1.9 μg/l

[1] Calculated by applying a modified "one-hit" extrapolation model described in the FR 15926, 1979. Since the extrapolation model is linear to low doses, the additional lifetime risk is directly proportional to the water concentration. Therefore, water concentrations corresponding to other risk levels can be derived by multiplying or dividing one of the risk levels and corresponding water concentrations shown in the table by factors such as 10, 100, 1000 and so forth.

[2] Twenty-one percent of the DPH exposure results from the consumption of aquatic organisms which exhibit an average bioconcentration potential of 29 fold. The remaining percent of DPH exposure results from drinking water.

Concentration levels were derived assuming a lifetime exposure to various amounts of DPH, (1) occurring from the consumption of both drinking water and aquatic life grown in water containing the corresponding DPH concentrations and, (2) occurring solely from consumption of aquatic life grown in the waters containing the corresponding DPH concentrations.

Although a total exposure evaluation for DPH is desirable there are no data to support a total exposure analysis. The criteria presented, therefore, assume an incremental risk from assumed ambient water exposure only.

For DPH the case for criterion development is based upon the existence of carcinogenicity responses in animals (rats and mice).

Because of the lack of investigations for other chronic and acute responses, there is no information on other effects in either human or animal systems. Thus, the criterion proposed should be considered as precautionary until further studies can be used in the overall toxicity evaluations.

Summary of Pertinent Data

The water quality criterion for 1,2-diphenylhydrazine is based on the induction of hepatocellular carcinomas and neoplastic nodules in male Fischer 344 rats, exposed to 0.03 percent (300 ppm) 1,2-diphenylhydrazine in the diet *ad libitum* for 78 weeks (NCI, 1978).[1] The incidence of hepatocellular carcinomas and neoplastic nodules was 37/49 and 1/48 in the treated and control groups, respectively. The criterion was calculated from the following parameters:

$n_t = 37$
$N_t = 49$
$n_c = 1$
$N_c = 48$
Le = 104 weeks
le = 78 weeks
L = 104 weeks
$d^* = 15$ mg/kg/day
F = .0187 kg/day
R = 29
W = 0.375 kg

Based on these parameters, the "one-hit" slope (B_H) is 0.715 $(mg/kg/day)^{-1}$. The resulting water concentration of 1,2-diphenylhydrazine, calculated to keep the individual lifetime cancer risk below 10^{-5}, is 0.40 μg/l.

*The dose (expressed as mg/kg (body weight)/day) is based on the assumption that the amount of diet consumed by rats each day was five percent of their body weight.

0.05 × 0.375 kg = 0.01875 kg diet/day.

0.01875 kg diet/day × 300 mg/kg = 5.625 mg 1,2 DPH/day.

5.625 mg 1,2 DPH/day/0.375 kg = 15 mg/kg/day.

Endosulfan

Criteria Summary

Freshwater Aquatic Life. For endodulfan the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.042 μg/l as a 24–hour average and the concentration should not exceed 0.49 μg/l at any time.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for endosulfan can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. For the protection of human health from the toxic properties of endosulfan ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.1 mg/l.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of endosulfan is the Final Acute Value of 0.49 μg/l and the 24-hour average concentration is the Final Chronic Value of 0.042 μg/l. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For endosulfan the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.042 μg/l as a 24-hour average and the concentration should not exceed 0.49 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 0.49 μg/l
Final Invertebrate Acute Value = 0.60 μg/l
Final Acute Value = 0.49 μg/l
Final Fish Chronic Value = 0.042 μg/l
Final Invertebrate Chronic Value = 0.84 μg/l
Final Plant Value = 2,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 0.042 μg/l
0.44 × Final Acute Value = 0.22 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for endosulfan using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 0.061 μg/l
Final Invertebrate Acute Value = 0.040 μg/l
Final Acute Value = 0.040 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 1,000 μg/l
Residue Limited Toxicant
Concentration = not available

Final Chronic Value = 1,000 μg/l
0.44 × Final Acute Value = 0.018 μg/l

Human Health. Establishing a scientific basis for evaluating the hazard of endosulfan to man is difficult. At very high levels of acute exposure, humans show central nervous system (CNS) symptoms and may die. Several studies report endosulfan has been used for suicides.

Workers who failed to use good safety practices (i.e., to cover skin and use respiratory protection) have died from endosulfan exposure. In one incident, three persons exposed showed CNS symptoms; two of them died. It therefore appears that the most toxic potential effect to man is that of CNS toxicity since the available data indicate a lack of carcinogenic, mutagenic, or teratogenic potential. The absence of reports on toxic effects associated with the proper use of endosulfan (particularly such effects as skin sensitization or other human symptoms) has been noted.

There appears to be considerable species variation in toxic effects. Of the species tested with endosulfan, cattle are the most sensitive to the neurotoxic effects and would therefore be a "worst case" model for human toxicity. There are much more controlled toxicity data on rodents, but cattle appear to be closer in sensitivity and effects to man. Data on CNS toxicity to cattle are presented in Table 13.

Table 13.—*Lethality and CNS Toxicity of Endosulfan in Cattle*

Dose, route	Number animals exposed	Time to CNS toxicity (hours)	Percent exposed showing CNS effects	Time to death (days)	Percent exposed dying
12.5 mg/kg, oral	2	10	100	6	50
0.12 percent formulation, dermal	250	5	20	1	4
4 percent dust, dermal	5	2	100	1	80
35 percent powder, dermal	30	5	(1)	(2)	50

[1] Apparently 100 percent.
[2] Hours to days.

The relevance of these high exposure levels to a water quality criterion presents additional sources of calculation error. The CNS toxicity in these studies is an acute symptom of high exposure. All reported human poisonings, however, have resulted from accident, human error, or suicidal intention. The reported poisonings of man and the most sensitive other mammal, cattle, have occurred after acute, high level exposure to concentrated endosulfan. These levels will not occur in drinking water. The key question then is, are there any data in the toxicology reports or studies to indicate that CNS effects can occur after chronic, very low level exposure to endosulfan?

Tiberin, et al. reported occasional EEG alteration in one of three men one year after a convulsive seizure following exposure to endosulfan. Terziev, et al. report that autopsy on an endosulfan suicide case showed "changes in the neurons" among lesions in other organs. In female rats, exposed for 78 weeks and orally autopsied or necropsied, cause of death was not indicated in the report. Rats, although more resistant to toxicity than man or cattle, demonstrate no histopathological changes in the brain after receiving high doses of endosulfan orally for 78 weeks, or most of a lifetime.

Cerebral hemorrhage was reported in seven female rats that died early in the study (week 21) but the absence of lesions at even higher and more long-term dosage suggested to the authors that these deaths were not compound-related. Several lesions were present in the male rats and mice that died early in these endosulfan feeding studies. The most prevalent lesions included nephropathy, parathyroid hyperplasia and testicular atrophy, all without clear dose response pattern.

An important question is "Do the apolar metabolites of endosulfan remain in the body to produce chronic effects if endosulfan is ingested in low level quantities over a long term?" No controlled metabolic studies in man have been reported, although Demeter and Heyndrickx report that endosulfan sulfate is a metabolite in humans. This metabolite is approximately as toxic to mice as the parent isomers but no specific CNS effects were reported (based on toxicity trials on the pure compound).

The toxicity of endosulfan is somewhat greater in animals with deficiencies of dietary protein. The differences in even a dose as high as an LD50 are not great enough, however, to ascribe any potential human hazard to this mechanism or to suggest that protein-deprived humans would be more sensitive to chronic exposure to endosulfan in drinking water.

It can be concluded that (a) the controlled studies uniformly report CNS toxicity following acute high level exposure and (b) there has been no indication reported of specific lesions in mammals related to mortality following chronic exposure.

A water quality criterion could be based on the lowest no-effect level (NOEL) reported for endosulfan in test species. Available data on no-effect levels are summarized in Table 14.

The lowest NOEL reported in the published literature is 2.0 mg endosulfan per kilogram feed when fed to mice for 78 weeks (Weisburger, et al. 1978) [1] This dose corresponds to 0.4 mg endosulfan/kilogram body weight per day for a typical 25 gram mouse consuming 5 grams feed/day:

$$\left(\frac{2.0\ \text{mg endosulfan}}{1{,}000\ \text{g feed}}\right)\left(\frac{5\ \text{g feed}}{\text{mouse-day}}\right)\left(\frac{\text{mouse}}{0.025\ \text{Kg}}\right) = 0.4\ \text{mg/Kg/day}$$

Applying a 0.01 animal to human uncertainty factor to this dosage gives an upper limit for nonoccupational daily exposure (ADI) of 0.28 mg/kg body weight for a 70 kg person:

$$\left(\frac{0.4\ \text{mg}}{\text{Kg-day}}\right)\quad(0.01)\quad\left(\frac{70\ \text{Kg}}{\text{person}}\right) = 0.28\ \text{mg/day}$$

[1] Weisburger, J.H., et al. 1978. Bioassay of endosulfan for possible carcinogenicity. National Cancer Institute Division of Cancer Cause and Prevention, National Institutes of Health, Public Health Service, U.S. Department of Health, Education, and Welfare, Bethesda, Maryland, Pub. 78-1312. Report by Hazleton Laboratories to NCI, NCI-CG-TR-62.

For the purpose of establishing a water quality criterion, human exposure to endosulfan is considered to be based on ingestion of 2 l of water and 18.7 g of fish/day. The amount of water ingested is approximately 100 times greater than the amount of fish consumed. The fish bioconcentration factor for endosulfan of 28 has been established.

Table 14.—*No-Effect Dose Levels for Endosulfan on Different Species and Biochemical Parameters*

Species	Organ/tissue	Effect observed	No-effect dose	Route administered [1]
Rats		Lethality	≅55 mg/kg=LD_{50}	Acute oral (Intragastric).
Rat		Lethality	40 mg/kg=LD_{50}	Acute oral.
Rat	Liver	Cholinesterase inhibition	68 mg/kg minimum	Acute oral.
Rat	Liver	Microsome enzyme function	50 ppm diet	Diet (2 weeks).
Rat	Embryo	Teratogenicity	10 mg/kg	Oral (Gestation Day 7–14).
Rat (female Osborne-Mendel)		Lethality	445 ppm diet	Diet (78 weeks).
Hamsters		Lethality	70 mg/kg	Acute oral.
Hamsters	Liver	Enzyme inhibition: GPT, LDH	134 mg/kg minimum	Acute Oral.
Mice		Weight depression	3.2 ppm diet	Diet (6 weeks).
Mice (female B6C3F1)		Lethality	2.0 ppm diet	Diet (78 weeks).
Rabbit	Eye	Inflammation and irritation	1:1,000 aqueous	Instillation.
Rabbit	Eye	Inflammation and irritation	20 pct aqueous solution	Instillation.
Rabbit	Skin	Irritation	100 mg/kg	Dermal.
Chickens	Egg	Hatchability	0.07 mg/egg	Yolk injection.
Dog		Gross and microscopic lesions	0.75 mg/kg/day	Oral (52 weeks).
Salmonella typhimurium	Strains TA98, 100, 1534, and 1976.	Base-pair substitution (mutagenicity)	1.0 mg/plate	

[1] Single dose unless otherwise noted.

The equation for calculating the criterion for endosulfan content of water is:

$$(2)(X) + (0.0187)(F)(X) = ADI$$

where: 2 = amount of drinking water was consumed, l/day
X = endosulfan concentration in water, mg/l
0.0187 = amount of fish consumed, Kg/day
F = bioconcentration factor, mg endosulfan/Kg fish per mg endosulfan/l water
ADI = limit on daily exposure for a 70 Kg person

For F = 28
2X + (0.0187) (28) (X) = 0.28
2.5286 X = 0.28
X = 0.1 mg/l

Endrin

Criteria Summary

Freshwater Aquatic Life. For endrin the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.0020 μg/l as a 24-hour average and the concentration should not exceed 0.10 μg/l at any time.

Saltwater Aquatic Life. For endrin the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.0047 μg/l as a 24-hour average and the concentration should not exceed 0.031 μg/l at any time.

Human Health. For the protection of human health from the toxic properties of endrin ingested through water and contaminated organisms, the ambient water criterion is determined to be 1 μg/l.

Freshwater Aquatic Life. The maximum concentration of endrin is the Final Acute Value of 0.10 μg/l and the 24-hour average concentration is the Final Chronic Value of 0.0020 μg/l. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 0.10 μg/l
Final Invertebrate Acute Value = 0.30 μg/l
Final Acute Value = 0.10 μg/l
Final Fish Chronic Value = 0.033 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 480 μg/l
Residue Limited Toxicant Concentration = 0.0020 μg/l
Final Chronic Value = 0.0020 μg/l
0.44 x Final Acute Value = 0.044 μg/l

Saltwater Aquatic Life. The maximum concentration of endrin is the Final Acute Value of 0.031 μg/l and the 24-hour average concentration is the Final Chronic Value of 0.0047 μg/l. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 0.056 μg/l
Final Invertebrate Acute Value = 0.031 μg/l
Final Acute Value = 0.031 μg/l
Final Fish Chronic Value = 0.028 μg/l
Final Invertebrate Chronic Value = 0.0075 μg/l
Final Plant Value = 0.2 μg/l
Residue Limited Toxicant Concentration = 0.0047 μg/l
Final Chronic Value = 0.0047 μg/l
0.44 x Final Acute Value = 0.014 μg/l

Human Health. The limited teratogenic and mutagenic studies on endrin suggest that effects are induced with high endrin doses. However, an unusual administration route was used and unrealistically high endrin levels were employed in these studies. Such levels do not occur in water supplies under normal circumstances, therefore, the results of these studies were not used as the basis for the criterion. More toxicological data must be gathered about these potential effects of endrin before a final conclusion can be reached. The available data do not indicate that endrin is carcinogenic.

On the basis of long-term dietary studies in mammals and occupational exposures in man, a realistic water criterion may be proposed. Maximum no-effect dietary levels of endrin reported for experimental animals are:

Species	Dose level (duration)
Mouse.....	1 mg/kg (lifetime).
Rat.....	1 mg/kg (2 Years).
Rat.....	1 mg/kg (established no-effect level).
Hamster....	1.5 mg/kg (no effect level) (one day).
Dog.....	0.1 mg/kg (128 days)
Dog.....	1 mg/kg (established no-effect level).

Extrapolation of the 0.1 mg/kg no-effect dietary level for the dog to man is reasonable. Since experimental studies of chronic human ingestion are not available (but acute exposure data are), and valid long-term animal feeding studies have been done in more than one species, an uncertainty factor of 100 may be used in the absence of any indication of carcinogenicity in arriving at a water criterion. In deriving a water quality criterion, human exposure to endrin was assumed to come from daily ingestion of 2 l of water and 18.7 g of fish with a bioconcentration factor of 1900 for endrin. Using a no-effect dose level of 0.1 mg/kg, the total allowable intake for a 70-kg man is:

$$0.1 \text{ mg endrin/kg} \times 70 \text{ kg} = \frac{7 \text{ mg/day}}{100 \text{ (uncertainty factor)}} = 70 \text{ ug/day}$$

The criterion for endrin is thus:

$$x = \frac{70 \text{ ug/day}}{2/1 + (0.0187 \text{ kg} \times 1900)} = 1.87 \text{ ug/l}$$

This approximates closely the 1 μg/l maximum allowable concentration for endrin proposed by the Public Health Service for drinking water. It is therefore, recommended that the endrin criterion be established at 1 μg endrin/l,

* It should be noted that, if endrin was present in waters from which edible fish were located and if these fish concentrate endrin by a factor of 1900, this criterion may not be sufficient to protect a special high risk group (i.e., pregnant women who consume a single dose of endrin contaminated fish). Given the bioconcentration factor, fish in water at the maximum recommended concentration of 1 μg/l, may contain 1.9 μg/g endrin. A 250/g portion of fish would contain approximately 0.5 mg endrin (or 0.01 mg/kg for a 50/kg female). This dose provides a margin of safety of only 150 over the NOEL of 1.5 mg/kg for teratogenicity in the hamster. The adequacy of this margin of safety is highly questionable, especially given the likelihood of consumption of more than 250/g of fish at a given time. The recommended water quality criterion of 1 μg/l was based on a chronic exposure study, teratologic outcomes are more likely to occur with acute exposures at critical times in gestation.

Ethylbenzene

Criteria Summary

Freshwater Aquatic Life. For freshwater aquatic life, no criterion for ethylbenzene can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for ethylbenzene can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. For the protection of human health from the toxic properties of ethylbenzene ingested through water, the ambient water quality criterion is 1.1 mg/l.

Basis for the Criteria

Freshwater Aquatic Life. No freshwater criterion can be derived for ethylbenzene using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 10,000 μg/l
Final Invertebrate Acute Value = 3,000 μg/l
Final Acute Value = 3,000 μg/l
Final Fish Chronic Value = greater than 33 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = greater than 440,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = greater than 33 μg/l
0.44 × Final Acute Value = 1,300 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for ethylbenzene using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 41,000 μg/l
Final Invertebrate Acute Value = 1,500 μg/l
Final Acute Value = 1,500 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = greater than 440,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = greater than 440,000 μg/l
0.44 × Final Acute Value = 660 μg/l

Human Health. The threshold limit value (TLV) of 434 mg/m³ (100 ppm) EB represents what is believed to be a maximal concentration to which a worker may be exposed for eight hours per day, five days per week over his working lifetime without hazard to health or well-being (Amer. Conf. Gov't Ind. Hyg., 1977).[1] To the TLV, Stokinger and Woodward (1958)[2] apply terms expressing respiratory volume during an eight hour period (assumed to be 10 m³) and a respiratory absorption coefficient appropriate to the substance under consideration. In addition, the five-day-per-week occupational exposure is often converted to a seven-day-per-week equivalent in keeping with the more continuous pattern of exposure to drinking water.

According to the model, the amount of ethylbenzene that may be taken into the bloodstream and presumed to be noninjurious and which, hence, may be taken in water each day is:

435 mg/m³	x 10 m³	x 0.5	x 5/7 week	= 1555 mg/day
(TLV)	Respiratory intake term	Respiratory absorption coefficient	Proportion of week exposed	Maximum noninjurious intake

A safety factor of 1000 is used since no long-term or acute human data are available, and there is very little information from experimental animals (Natl. Acad. Sci., 1977).[3] Thus, 1555 mg/day divided by 1000=1.555 or 1.6 mg/day.

To calculate an acceptable amount of EB in ambient water, the methodology assumes a maximal daily intake of 2

[1] American Conference of Governmental Industrial Hygienists. 1977. Threshold limit values for chemical substances and physical agents in the workroom environment with intended changes for 1977.

[2] Stokinger, H.E., and R.L. Woodward. 1958. Toxicologic methods for establishing drinking water standards. Jour. Am. Water Works Assoc. 50: 515.

[3] National Academy of Sciences 1977. Drinking water and health. Washington, D.C.

liters of water per day, the consumption of 18.7 grams of fish/shellfish per day, a bioconcentration factor of 42 for fish and 50 percent absorption.

44	(2+42 (0.0187))	0.5	= 1.6 mg/day
Upper intake limit—	Oral intake term	Gastrointestinal absorption coefficient	Maximum nonanxious intake

Solving for x, the value derived is 1.1 mg/l. According to Stokinger and Woodward (1958)[2] "This derived value represents an approximate limiting concentration for a healthy adult population; it is only a first approximation in the development of a tentative water quality criterion. * * * several adjustments in this value may be necessary * * * Other factors, such as taste, odor and color may outweigh health considerations because acceptable limits for these may be below the estimated health limit."

It should also be noted that the basis for the above recommended limit, the TLV for EB, is the avoidance of irritation, rather than chronic effects (Am. Conf. Ind. Hyg., 1977). Should chronic effects data become available, both TLV's and recommendations based on them will warrant reconsideration.

In summary, based on a threshold limit value, and an uncertainty factor of 1000, the criterion level for ethylbenzene corresponding to the calculated acceptable daily intake of 1.6 mg/day, is 1.1 mg/l. Drinking water contributes 72 percent of the assumed exposure while eating contaminated fish products accounts for 28 percent. The criterion level can alternatively be expressed as 2.0 mg/l if exposure is assumed to be from the consumption of fish and shellfish products alone.

Haloethers

Criteria Summary

Freshwater Aquatic Life. For 4-bromophenylphenyl ether the criterion to protect freshwater aquatic life as derived using the Guidelines is 6.2 μg/l as a 24-hour average and the concentration should not exceed 14 μg/l at any time.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for 4-bromophenylphenyl ether can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. Because of a lack of adequate toxicological data on non-human mammals and humans, protective criteria cannot be derived at this time for any haloether discussed in this document.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of 4-bromophenylphenyl ether is the Final Acute Value of 14 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 4-bromophenylphenyl ether the criterion to protect freshwater aquatic life as derived using the Guidelines is 6.2 μg/l as a 24-hour average and the concentration should not exceed 14 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

4-bromophenylphenyl ether

Final Fish Acute Value = 690 μg/l
Final Invertebrate Acute Value = 14 μg/l
Final Acute Value = 14 μg/l
Final Fish Chronic Value = 9.1 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 9.1 μg/l
0.44 × Final Acute Value = 6.2 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for any haloether using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Human Health. 1. Bis(2-chloroisopropyl)ether: A reliable criterion cannot be calculated for this ether because a long-term "no adverse effect" level cannot be established for mammals. A criterion might be derived from a bioassay described in the criteria document using non-tumor pathology. However, in the low dose groups, both male and female mice evidenced an increased incidence of centrilobular necrosis of the liver which was not seen in the high dose groups.

2. Chlorinated Aromatic Ethers: As indicated in Section V.A., the TLV for chlorophenyl phenyl ether is 500 μg/m³. By a process analogous to that used by Stokinger and Woodward, this standard could be used to calculate a water criterion. However, since the TLV for these compounds is based on preventing chloracne, rather than chronic toxicity, such a calculation would not be appropriate. Because of the lack of data on both toxicologic effects and environmental contamination, the hazard posed by these compounds cannot be estimated.

Halomethanes

Criteria Summary

Freshwater Aquatic Life. For methyl chloride the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 7,000 μg/l as a 24-hour average and the concentration should never exceed 16,000 μg/l at any time.

For methyl bromide the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 140 μg/l as a 24-hour average and the concentration should never exceed 320 μg/l at any time.

For methylene chloride the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 4,000 μg/l as a 24-hour average and the concentration should never exceed 9,000 μg/l at any time.

For bromoform the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 840 μg/l as a 24-hour average and the concentration should never exceed 1,900 μg/l at any time.

Saltwater Aquatic Life. For methyl chloride the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 3,700 μg/l as a 24-hour average and the concentration should never exceed 8,400 μg/l at any time.

For methyl bromide the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 170 μg/l as a 24-hour average and the concentration should never exceed 380 μg/l at any time.

For methylene chloride the criterion to protect saltwater aquatic life as derived using procedures other than the

Guidelines is 1,900 μg/l as a 24-hour average and the concentration should never exceed 4,400 μg/l at any time.

For bromoform the criterion to protect saltwater aquatic life as derived using the Guidelines is 180 μg/l as a 24-hour average and the concentration should never exceed 420 μg/l at any time.

Human Health. For the protection of human health from the toxic properties of halomethanes ingested through water and through contaminated aquatic organisms, the ambient water criteria for the halomethanes discussed in this document are:

Compound	Criterion level (μg/l)
Chloromethane (Methyl Chloride)	2
Bromomethane (Methyl Bromide)	2
Dichloromethane (Methylene Chloride)	2
Bromodichloromethane	2
Tribromomethane (Bromoform)	2
Dichlorodifluoromethane	3,000
Trichlorofluoromethane	32,000

Basis for the Criteria

Freshwater Aquatic Life. No freshwater criterion can be derived for any halomethane using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available.

However, results obtained with halomethanes and freshwater and saltwater fish and invertebrate species indicate how criteria may be estimated.

For bromoform and methylene chloride with freshwater and saltwater organisms and for chloroform and carbon tetrachloride with freshwater organisms, the Final Invertebrate Acute Value divided by the Final Fish Acute Value is 0.46, 0.24, 0.16, 0.090, 0.11, and 0.17 respectively, for an average of 0.21. Multiplying this value times the Final Acute Values for methyl chloride and methyl bromide with freshwater fish results in estimated freshwater Final Invertebrate Acute Values of 0.21 x 77,000 μg/l = 16,000 μg/l and 0.21 x 1,500 μg/l = 320 μg/l respectively. Thus the Final Acute Values for methyl chloride and methyl bromide would be based on these estimated values and are 16,000 μg/l and 320 μg/l respectively.

For chloroform and freshwater organisms the Final Chronic Value is about the same as 0.44 times the Final Acute Value, and for bromoform and saltwater organisms the Final Chronic Value is greater than 0.44 times the Final Acute Value, even though a chronic value is available for fish or invertebrates in both cases. Therefore, it seems reasonable to estimate criteria for other halomethanes and freshwater organisms using 0.44 times the Final Acute Value.

The estimated maximum concentration of methyl chloride is the Final Acute Value of 16,000 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For methyl chloride the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 7,000 μg/l as a 24-hour average and the concentration should never exceed 16,000 μg/l at any time.

The estimated maximum concentration of methyl bromide is the Final Acute Value of 320 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For methyl bromide the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 140 μg/l as a 24-hour average and the concentration should never exceed 320 μg/l at any time.

The maximum concentration of methylene chloride is the Final Acute Value of 9,000 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For methylene chloride the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 4,000 μg/l as a 24-hour average and the concentration should never exceed 9,000 μg/l at any time.

The maximum concentration of bromoform is the Final Acute Value of 1,900 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For bromoform the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 840 μg/l as a 24-hour average and the concentration should never exceed 1,900 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Methyl Chloride

Final Fish Acute Value = 77,000 μg/l
Final Invertebrate Acute Value = not available
Final Acute Value = 77,000 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = not available
0.44 x Final Acute Value = 34,000 μg/l

Methyl Bromide

Final Fish Acute Value = 1,500 μg/l
Final Invertebrate Acute Value = not available
Final Acute Value = 1,500 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = not available
0.44 x Final Acute Value = 660 μg/l

Methylene Chloride

Final Fish Acute Value = 38,000 μg/l
Final Invertebrate Acute Value = 9,000 μg/l
Final Acute Value = 9,000 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = greater than 660,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = greater than 660,000 μg/l
0.44 x Final Acute Value = 4,000 μg/l

Bromoform

Final Fish Acute Value = 4,100 μg/l
Final Invertebrate Acute Value = 1,900 μg/l
Final Acute Value = 1,900 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 110,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 110,000 μg/l
0.44 x Final Acute Value = 840 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for methylene chloride, methyl bromide or methyl chloride using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available.

However, results obtained with halomethanes and freshwater and saltwater fish and invertebrate species indicate how criteria may be derived.

For bromoform and methylene chloride with freshwater and saltwater organisms and for chloroform and carbon tetrachloride with freshwater organisms, the Final Invertebrate Acute Value divided by the Final Fish Acute Value is 0.46, 0.24, 0.16, 0.090, 0.11, and 0.17 respectively, for an average of 0.21. Multiplying this value times the Final Acute Values for methyl chloride and

methyl bromide with saltwater fish results in estimated saltwater Final Invertebrate Acute Values of 0.21 × 40,000 μg/l = 8,400 μg/l and 0.21 × 1,800 μg/l = 380 μg/l respectively. Thus the Final Acute Values for methyl chloride and methyl bromide would be based on these estimated values and are 8,400 μg/l and 380 μg/l respectively.

For chloroform and freshwater organisms the Final Chronic Value is about the same as 0.44 times the Final Acute Value, and for bromoform and saltwater organisms the Final Chronic Value is greater than 0.44 times the Final Acute Value, even though a chronic value is available for fish or invertebrate species in both cases. Therefore, it seems reasonable to estimate criteria for other halomethanes and saltwater organisms using 0.44 times the Final Acute Value.

The estimated maximum concentration of methyl chloride is the Final Acute Value of 8,400 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For methyl chloride the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 3,700 μg/l as a 24-hour average and the concentration should never exceed 8,400 μg/l at any time.

The estimated maximum concentration of methyl bromide is the Final Acute Value of 380 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For methyl bromide the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 170 μg/l as a 24-hour average and the concentration should never exceed 380 μg/l at any time.

The maximum concentration for methylene chloride is the Final Acute Value of 4,400 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration. For methylene chloride the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 1,900 μg/l as a 24-hour average and the concentration should never exceed 4,400 μg/l at any time.

The maximum concentration of bromoform is the Final Acute Value of 420 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For bromoform the criterion to protect saltwater aquatic life as derived using the Guidelines is 180 μg/l as a 24-hour average and the concentration should never exceed 420 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Methyl Chloride

Final Fish Acute Value = 40,000 μg/l
Final Invertebrate Acute Value = not available
Final Acute Value = 40,000 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant Concentration = not available
Final Chronic Value = not available
0.44 × Final Acute Value = 18,000 μg/l

Methyl Bromide

Final Fish Acute Value = 1,800 μg/l
Final Invertebrate Acute Value = not available
Final Acute Value = 1,800 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant Concentration = not available
Final Chronic Value = not available
0.44 × Final Acute Value = 790 μg/l

Methylene Chloride

Final Fish Acute Value = 49,000 μg/l
Final Invertebrate Acute Value = 4,400 μg/l
Final Acute Value = 4,400 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = greater than 660,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = greater than 660,000 μg/l
0.44 × Final Acute Value = 1,900 μg/l

Bromoform

Final Fish Acute Value = 2,600 μg/l
Final Invertebrate Acute Value = 420 μg/l
Final Acute Value = 420 μg/l
Final Fish Chronic Value = 1,400 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 12,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 1,400 μg/l
0.44 × Final Acute Value = 180 μg/l

Human Health. Data on current levels of the halomethanes in water, food, and ambient air are not sufficient to permit adequate estimates of total human exposures from these media. Available data discussed in an earlier section of this report (Occurrence) indicate that the greatest human exposure to the trihalomethanes occurs through the consumption of liquids (including drinking water and beverages containing it), and that exposure to chlorofluorocarbons, chloromethane, dichloromethane, and bromomethane occurs primarily by inhalation.

Observed correlations among concentrations of trihalomethanes in finished water are attributed to the presence of common organic precursor materials in raw water.

Among the halomethanes considered in this report, bromodichloromethane seems to predominate in drinking waters. Concentrations of bromodichloromethane in raw and finished water samples are generally in the area of 6 μg/l or less, and thus represent a reasonable upper limit for anticipated levels of any halomethane in water (excluding chloroform and carbon tetrachloride).

Recent reports showing that chloromethane, bromomethane, tribromomethane, dichloromethane, and bromodichloromethane exhibit carcinogenic and/or mutagenic effects in certain bioassay systems suggest the need for conservatism in the development of water quality criteria for the protection of human health. Since the presently available carcinogenicity data base for these compounds is judged qualitatively informative but quantitatively inadequate for risk extrapolation, an alternative approach is necessary for criteria development.

At present levels in relatively unpolluted raw and finished waters (10 μg/l), the halomethanes pose little threat for the production of non-carcinogenic toxic effects in humans. However, the possibility of carcinogenic effects must be evaluated in light of current and past exposures to halomethanes via water supplies. Limited epidemiologic studies have failed to show a clear association between cancer mortality and bromine-containing trihalomethanes at levels in water of about 5–10 μg/l. Since the possible association between human cancers and halomethanes cannot presently be disproven, it would be wise to limit their presence in water to no more than the median levels which are currently encountered (pending better human risk data). Thus, a maximum level of 6 μg/l in raw and finished

waters could be considered as acceptable for bromomethane, chloromethane, dichloromethane, tribromomethane, and bromodichloromethane. From the limited animal bioassay data which are available in the strain A mouse lung tumor system, a daily human intake of halomethanes at 12 μg/day (6 μg/l × 2 l/day) represents a dose which is about 100,000-fold less than the minimum daily dose of tribromomethane which caused a significant increase in tumor formation in mice. Since there exists considerable uncertainty over the human carcinogenic risks of halomethanes, a safety factor of 100,000 seems prudent for the development of an interim standard for all halomethanes pending the results of further research.

The 6 μg/l maximum acceptable concentration for bromomethane, chloromethane, tribromomethane, dichloromethane, and bromodichloromethane does not take into consideration the contribution to total exposure from air and food. Exposure via these media cannot be accurately predicted, although it is likely that it is sufficiently large for chloromethane, dichloromethane, and bromomethane to warrant the recommendation of a water quality criterion below 6 μg/l. Present levels of these three compounds are generally much less than 6 μg/l and it is not likely that current anthropogenic sources would significantly increase their level in water.

For criteria setting purposes it is recommended that a criterion of 2 μg/l be adopted for this group of halomethanes, based upon analogy to the structure and biological activity of chloroform. Despite the presently inadequate data base for most of these compounds, it can nevertheless be predicted that similar biological effects, including neoplastic transformation, may be encountered. Since the recommended criterion for chloroform was derived from reliable experimental data, it represents the most applicable value for all of the halomethanes which are suspected carcinogens.

Evidence for mutagenicity of dichlorodifluoromethane is equivocal and there is no evidence as yet for carcinogenicity as a result of direct exposure. Chronic toxicity data for dichlorodifluoromethane are quite limited. In the only long-term (two years) feeding study reported (U.S. EPA, 1976,[1] citing Sherman, 1974 [2]) the maximum dose level producing no observed adverse effect (in dogs) was 80 mg/kg/day. Applying an uncertainty factor of 1000 (NAS, 1977 [3]) to this data yields a presumptive "acceptable daily intake" of 0.08 mg/kg/day. For a man weighing 70 kg, consuming two liters of water per day and absorbing at 100 percent efficiency, and assuming that the water is the sole source of exposure, this acceptable intake level translates into a criterion level as follows: (0.08) (70)/2 = 2.8 mg/l.

There is no evidence for mutagenicity of trichlorofluoromethane, and no evidence as yet for carcinogenicity as a result of direct exposure. The only data on toxicity testing using prolonged exposure at relatively low test concentrations are from a report (Jenkins, et al. 1970 [4]) which showed no observed adverse effects in rats and guinea pigs exposed continuously by inhalation for 90 days at 5,610 mg/m ^{3}. If the reference man weighing 70 kg breathed this atmosphere and absorbed the compound at 50 percent efficiency, his estimated exposure dose would be 5,610 × 23 × 0.5 = 64,515 mg/day or 922 mg/kg/day. Applying an uncertainty factor of 1000 (NAS, 1977 [3]) to this data yields a presumptive "acceptable daily intake" of 0.922 mg/kg/day for trichlorofluoromethane. Assuming man's weight to be 70 kg and his absorption of ingested compound to be 100 percent efficient, and that his sole source of exposure is water consumed at two liters/day, the acceptable intake is translated into a criterion level as follows: (0.922) (70)/2 = 32.3 mg/l.

Criterion levels intended to protect the public against unacceptable risk of toxicity, mutagenicity, or carcinogenicity from exposure to selected halomethanes in water for consumption, derived as described in the foregoing text, are summarized as follows (rounded off):

Compound	(mg/l)
Bromodichloromethane	2×10^{-3}
Tribromomethane	2×10^{-3}
Dichloromethane	2×10^{-3}
Bromomethane	2×10^{-3}
Chloromethane	2×10^{-3}
Dichlorodifluoromethane	3
Trichlorofluoromethane	[illegible]

[1] U.S. EPA. 1976. Environmental hazard assessment report, major one-and two-carbon saturated fluorocarbons, review of data. EPA 560/8-76-003. Off. Toxic Subst. Washington, D.C.

[2] Sherman, H. 1974. Long-term feeding studies in rats and dogs with dichlorodifluoromethane (Freon 12 Food Freezant). Unpubl. rep. Haskell Lab.

[3] National Academy of Sciences. 1977. Drinking water and health. Washington, D.C.

[4] Jenkins, L. J., et al. 1970. Repeated and continuous exposure of laboratory animals to trichlorofluoromethane. Toxicol. Appl. Pharmacol. 16:133.

Adoption of the presently recommended criterion for choloroform (2 μg/l) as the recommended level for other possibly carcinogenic halomethanes should provide an adequate margin of safety in the absence of sufficient data for quantitative risk assessment. This criterion is intended to reduce carcinogenic risks to the public, and takes into account the fact that exposure to halomethanes also occurs through foods and via inhalation. Although the potential carcinogenicity of bromodichloromethane, tribromomethane, dichloromethane, bromomethane, and chloromethane cannot be adequately assessed at present, the adoption of an interim water quality standard in excess of 2 μg/l may be interpreted as approval to discharge larger quantities of these substances than of chloroform. Such a practice is clearly unwarranted until such time that concerns over possible carcinogenic activity have been resolved.

Isophorone

Criteria Summary

Freshwater Aquatic Life. The data base for freshwater aquatic life is insufficient to allow use of the Guidelines. The following recommendation is inferred from toxicity data for saltwater organisms.

For isophorone the criterion to protect freshwater aquatic life as derived using the Guidelines is 2,100 μg/l as a 24-hour average and the concentration should not exceed 4,700 μg/l at any time.

Saltwater Aquatic Life. For isophorone the criterion to protect saltwater aquatic life as derived using the Guidelines is 97 μg/l as a 24-hour average and the concentration should not exceed 220 μg/l at any time.

Human Health. For the protection of human health from the toxic properties of isophorone ingested through water, the criterion is 460 μg/l.

Basis for the Criteria

Freshwater Aquatic Life. No freshwater criterion can be derived for isophorone using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available.

Results obtained with isophorone and saltwater organisms indicate how a criterion may be estimated.

For isophorone and saltwater organisms, 0.44 times the Final Acute Value is less than the Final Chronic Value derived from results of an

embryo-larval test with the sheepshead minnow. Therefore, it seems reasonable to estimate a criterion for isophorone and freshwater organisms using 0.44 times the Final Acute Value.

The maximum concentration of isophorone is the Final Acute Value of 4,700 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects of freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For isophorone the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 2,100 μg/l as a 24-hour average and the concentration should not exceed 4,700 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 31,000 μg/l
Final Invertebrate Acute Value = 4,700 μg/l
Final Acute Value = 4,700 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 120,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 120,000 μg/l
0.44 × Final Acute Value = 2,100 μg/l

Saltwater Aquatic Life. The maximum concentration of isophorone is the Final Acute Value of 220 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For isophorone the criterion to protect saltwater aquatic life as derived using the Guidelines is 97 μg/l as a 24-hour average and the concentration should not exceed 220 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = not available
Final Invertebrate Acute Value = 220 μg/l
Final Acute Value = 220 μg/l
Final Fish Chronic Value = 7,700 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 110,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 7,700 μg/l
0.44 × Final Acute Value = 97 μg/l

Human Health. Based on the available data on the toxicological effects of isophorone absorption in both man and experimental animals, a calculated water quality criterion for isophorone can only be based upon a non-carcinogenic effect. Water quality criteria may therefore be derived from the TLV, acute oral LD_{50} values, or from subacute oral toxicity data using non-carcinogenic biological responses. Criteria derivations based on all three approaches are presented below.

Criterion Based on TLV: Stokinger and Woodward (1958) presented a method for calculating water quality criteria from TLV's. Essentially, this method consists of deriving an acceptable daily intake (ADI) from the TLV by making assumptions on breathing rate, and respiratory and gastrointestinal absorption. Stokinger and Woodward assumed that the daily total pollutant uptake from air at the TLV concentration can be safely tolerated, and that this safe quantity of pollutant per day can be similarly tolerated in drinking water. The ADI is then partitioned into permissible amounts from drinking water and from other sources.

The International Commission on Radiological Protection (1974) has estimated that the "reference man" breathes 7.6 m^3 of air during eight hours of "light activity." Since respiratory absorption rates are unknown, 50 percent absorption of inhaled isophorone will be assumed. In addition, the five day per week TLV may be converted to a seven day per week equivalent to reflect the more continuous pattern of exposure via drinking water. An ADI for man can be thus calculated from the TLV by multiplying by these factors:

$$28\ mg/m^3 \times 7.6\ m^3 \times 0.5 \times 5\ days/7\ days = 76\ mg/day$$

Since estimates of isophorone exposure from non-water sources are not available, it will be assumed that total isophorone exposure is attributable to the ingestion of drinking water and fish and shellfish. For the pupose of estimating a criterion it will be further assumed that the maximal daily intake of water is 2 liters, that the consumption of fish/shellfish amounts to 18.7 grams/day, and that the gastrointestinal absorption of isophorone is 100 percent. Also a bioconcentration factor of 16 has been calculated for fish (EPA, 1979b). A water quality criterion may then be calculated as:

$$\frac{76\ mg/man}{(2\ l \div [16 \times 0.0187]) \times 1.0} = 33\ mg/l$$

It should be noted that the TLV is based on the prevention of the irritant effects of isophorone on inhalation exposures, rather than on chronic effects. Consequently, the calculation of a criterion by this approach probably has little validity in this case.

Criterion Based on Acute Oral Toxicity Data, McNamara (1976) has suggested that data from acute exposures can be used to estimate chronic no-effect levels for toxic responses to chemical absorption. Based on an extensive review of the literature comparing the results of acute and chronic toxicity bioassays, McNamara noted that "for 95 percent of chemical compounds . . . [on which data were available] . . . LD_{50}/1000 will produce no effects in a lifetime." Using this approximation for isophorone, and an average oral LD_{50} value of 2 g/kg (Effects section), the no observable effect level for isophorone in rats can be estimated at 2 mg/kg/day. This value may be converted into an ADI by applying an appropriate uncertainty factor to account for species extrapolation and limitations of the data. Since the chronic no-effect dose is merely an estimate based on observed relationships between acute and chronic toxicity, an uncertainty factor of 1000 is recommended (see NAS, 1977, p. 804). Thus, the estimated ADI for man is 2 μg/kg or 140 μg/man, assuming a 70 kg body weight. By assuming that man consumes 2 liters of water per day, that man is additionally exposed daily to 18.7 grams of fish and shellfish which bioaccumulate isosphorone from water by a factor of 16, and that gastrointestinal absorption is 100 percent, the corresponding no adverse effect level in water can be calculated as

$$\frac{140\ \mu g/day}{(2\ l \div [16 \times 0.0187]) \times 1.0} = 61\ \mu g/l$$

Based on these calculations, the criterion for isophorone should not exceed 0.06 mg/l.

Criterion Based on Subacute Oral Data: As summarized in the Effects section, no significant effects were produced in beagle dogs by feeding isophorone in gelatin capsules at levels up to 150 mg/kg/day for 90 days (EPA, 1979a). Due to the fact that this study did not involve a truly chronic exposure, the NAS (1977) guidelines for establishing an acceptable daily intake for man are not directly applicable. McNamara (1976) has suggested, however, that subacute exposures can be used to estimate chronic no-effect exposure levels.

McNamara (1976) found that for 95 percent of chemical compounds for which data were available, a three month no-effect dose/10 will yield a level which should produce no adverse effects in a lifetime. By using this relationship, the chronic no-effect dose for dogs is calculated to be:

$$\frac{150\ \text{mg/kg}}{10} = 15\ \text{mg/kg}$$

The application of an uncertainty factor of 1000 is suggested to convert this value to an ADI (see NAS, 1977, p. 804). Therefore, an estimated ADI for man is 15 μg/kg or 1050 μg/man, assuming a 70 kg body weight. Consumption of 2 liters of water daily and of 18.7 grams of contaminated aquatic organisms which have a bioconcentration factor of 16 would result in, assuming gastrointestinal absorption of isophorone, a maximum permissible concentration of 0.46 mg/l for the ingested water:

$$\frac{1050\ \mu\text{g/day}}{(2\text{l} + [16 \times 0.0187]) \times 1.0} = 457\ \mu\text{g/l}$$

In conclusion, permissible levels for isophorone in water have been derived on the basis of a TLV (33 mg/l), acute oral toxicity data (0.06 mg/l) and a 90-day feeding study in dogs (0.46 mg/l). Although this exercise has yielded figures which may have some utility in the protection of human health, the presently available scientific data base is inadequate to support a reliable criterion. The most prudent approach at this time would be to recommend only an interim criterion pending the results of future research, including the planned NCI bioassay. An interim criterion of 0.46 mg/l could be recommended in cases where water is the sole source of exposure to isophorone, because the basis for this value is a well defined no-effect level derived from a higher vertebrate species (dog) subjected to subchronic oral exposure. Since current levels of isophorone in drinking water are usually less than 3 μg/l, although amounts as high as 9.5 μg/l have been reported, an ample margin of safety apparently exists.

Summary of Pertinent Data. Calculation of appropriate isophorone concentration in saturated air.

For a sample of ideal gas,

$PV = nRT$

where

P = pressure
V = volume
n = number of moles
R = universal gas constant
T = absolute temperature

Since n = g/mw, the ideal gas equation can be rearranged as follows to calculate the approximate number of grams of compound contained in a particular volume of gas at a specified temperature and pressure:

$$PV = \frac{g}{mw} RT$$

$$g = \frac{PV(mw)}{RT}$$

At 25°C, the vapor pressure of isophorone is 0.44 mm. Assuming a 1 liter volume of air,

$$g = \frac{\frac{0.44\text{mm}}{760\text{mm}} \times 1\ \text{liter} \times 138.21\ \frac{\text{g}}{\text{mole}}}{0.082\ \frac{\text{liter-atm}}{\text{mole-°K}} \times 298\text{°K}}$$

$$= 0.00327\ \text{g} = 3.27\ \text{mg}$$

The approximate ppm equivalent concentration of isophorone in saturated air can then be calculated from the relationship:

$$\frac{(\text{mg/l})\ (24{,}450\ \text{ml/mole})}{\text{mw}} = \text{ppm}$$

$$\frac{(3.27\ \text{mg/l})\ (24{,}450\ \text{ml/mole})}{138.21\ \text{g/mole}} = 578\ \text{ppm}$$

Naphthalene

Criteria Summary

Freshwater Aquatic Life. For freshwater aquatic life, no criterion for naphthalene can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for naphthalene can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. For the protection of human health from the toxic properties of naphthalene ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 143 μg/l.

Basis for the Criteria

Freshwater Aquatic Life. No freshwater criterion can be derived for napthalene using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 21,000 μg/l
Final Invertebrate Acute Value = 350 μg/l
Final Acute Value = 350 μg/l
Final Fish Chronic Value = greater than 33 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 33,000 μg/l
Residue Limited Toxicant 00 percent Concentration = not available
Final Chronic Value = greater than 33 μg/l
0.44 × Final Acute Value = 150 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for napthalene using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 300 μg/l
Final Invertebrate Acute Value = 20 μg/l
Final Acute Value = 20 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant Concentration = not available
Final Chronic Value = not available
0.44 × Final Acute Value = 8.8 μg/l

Human Health. All chronic toxicity studies using naphthalene have failed to demonstrate any carcinogenic activity except for those performed by Knake (1956). This author found an excess occurrence of lymphosarcoma when naphthalene was given by the subcutaneous route to rats, and lymphocytic leukemia when naphthalene was chronically painted on the skin of mice using benzene as a solvent. However, the naphthalene used in this study was derived from coal tar and contained ten percent or more unidentified impurities. Furthermore, a known experimental carcinogen, carbolfuchsin, was applied prior to each injection of naphthalene in the former study. In light of these defects, carcinogenicity data derived from this

study cannot be used as a basis for a naphthalene water criterion.

No other chronic toxicity studies are available that can be used as an adequate basis for a naphthalene criterion. Furthermore, there are no adequate epidemiologic studies that can be used as a basis.

The ACGIH (1971) has recommended a time-weighted threshold limit value for an industrially exposed population of 50 mg/m^3 (50 μg/l) of naphthalene vapor in air. This value was set to prevent workers with exposure to naphthalene vapors from getting eye irritation. It is unclear, however, whether exposures to water containing naphthalene in excess of this level (50 μg/l) might also result in mucous membrane irritation. Until further information is available on the direct irritant properties of naphthalene in water, the ACGIH threshold limit value cannot be used as a basis for a naphthalene water criterion.

Mahvi, et al. (1977) noted a dose related response by C57 B1/6J mice given intraperitoneal injections of naphthalene in sesame oil. No bronchiolar epithelial changes were noted in two control groups. The authors noted minimal bronchiolar epithelial changes in the treated group receiving 6.4 mg/kg body weight of naphthalene. Severe, reversible damage to bronchiolar epithelial cells was noted among two higher dosage groups. The results of this study can be used as the basis for the criterion. The minimal effect level of 6.4 mg/kg of body weight is equivalent to a 448 mg dose for a 70 kg man and can reasonably be used as a basis for calculating an acceptable daily dosage if it is reduced by a factor of 1000, which equals 448 μg, to protect sensitive individuals (NAS, 1977).

No pharmacokinetic data are available on the absorption of naphthalene by the oral route. Because of its high octanol: water partition coefficient (Krishnamurthy and Wasik, 1978), it is reasonable to expect that naphthalene in water should be nearly completely absorbed and an absorption efficiency of 100 percent can be assumed.

For the purposes of establishing a water quality criterion, human exposure to naphthalene is considered to be based on ingestion of 2 liters of water and 18.7 g of fish. Fish bioaccumulate naphthalene from water by a factor of 60.

With these considerations in mind, the following equation has been established:

$$2\,L \cdot X + (0.0187 \times 60) \cdot X = 448\ \mu g$$

Where:

448 μg = limit on daily exposure for a 70 kg person (ADI)
2 L = amount of drinking water consumed
0.0187 kg = amount of fish consumed
60 = bioaccumulation factor

Solving for X:

X = 143 μg/l

Thus, the water level would have to be limited to 143 μg/l to limit the daily intake of naphthalene to 448 μg.

Nickel

Criteria Summary

Freshwater Aquatic Life. For nickel the criterion to protect freshwater aquatic life as derived using the Guidelines is "$e^{(1.01 \cdot \ln(\text{hardness}) - 1.02)}$" as a 24-hour average and the concentration should not exceed "$e^{(0.47 \cdot \ln(\text{hardness}) + 4.19)}$" at any time.

Saltwater Aquatic Life. For nickel the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 220 μg/l as a 24-hour average and the concentration should not exceed 510 μg/l at any time.

Human Health. For nickel the criterion to protect human health is 50 μg/l/.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of nickel is equal to the Final Acute Value as given by $e^{(0.47 \cdot \ln(\text{hardness}) + 4.19)}$ and the 24-hour average concentration is the Final Chronic Value as given by $e^{(1.01 \cdot \ln(\text{hardness}) - 1.02)}$. No important adverse effects on freshwater organisms have been reported to be caused by concentrations lower than the 24-hour average concentration other than the possible changes in diatom diversity discussed in the Criterion Document.

Summary of Available Data. The concentrations below have been rounded to two significant figures. All concentrations herein are expressed in terms of nickel.

Final Fish Acute Value = $e^{(0.74 \cdot \ln(\text{hardness}) + 4.92)}$
Final Invertebrate Acute Value = $e^{(0.47 \cdot \ln(\text{hardness}) + 4.19)}$

Final Acute Value = $e^{(0.47 \cdot \ln(\text{hardness}) + 4.19)}$
Final Fish Chronic Value = $e^{(1.01 \cdot \ln(\text{hardness}) - 1.02)}$
Final Invertebrate Chronic Value = $e^{(1.01 \cdot \ln(\text{hardness}) + 0.13)}$

Final Final Plant Value = 100 μg/l
Residue Limited Toxicant Concentration = not available

Final Chronic Value = $e^{(1.01 \cdot (\text{hardness}) - 1.02)}$

Saltwater Aquatic Life. Criterion: for nickel the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 220 μg/l as a 24-hour average and the concentration should not exceed 510 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures. All concentrations herein are expressed in terms of nickel.

Final Fish Acute Value = 14,000 μg/l
Final Final Invertebrate Acute Value = 510 μg/l
Final Acute Value = 510 μg/l

Human Health. In arriving at a criterion for nickel, several factors must be taken into account. There is little evidence for accumulation of nickel in various tissues. Absorption through the gastrointestinal tract is minimal. Acute exposure of man to nickel is chiefly of concern in workplaces where nickel carbonyl or nickel dust are present at high levels. In these situations inhalation is the main route of entry and the lung is the critical organ although, in some instances of high exposure, the central nervous system may also be involved.

The major problem posed by nickel for the U.S. population at large is nickel hypersensitivity, mainly via contact with many nickel-containing commodities. Nickel could play a role in altering defense mechanisms against xenobiotic agents in the respiratory tract, leading to enhanced risk for respiratory tract infections.

While nickel has a possible role as a co-carcinogen in producing respiratory cancer, as suggested by animal studies, this remains to be demonstrated. There is no evidence for carcinogenicity due to the presence of nickel in water. The role of nickel as an essential element is a confounding factor in any risk estimate.

In order to develop a risk assessment based on toxicological effects other than carcinogenicity, dose-response data would be most helpful. However, while the frequency or extent of various effects of nickel are related to the level or frequency of nickel exposure in man, the relevant data do not permit any quantitative estimation of dose-response relationships. The lowest levels of nickel associated with adverse health effects, therefore, must be used in establishing a criterion level for nickel in drinking water.

To arrive at a risk estimate for nickel, a modification of the approach used for non-stochastic effects (Fed. Register 44(52):15980, March 15, 1979) has been adopted.

The studies cited in this document have not demonstrated a no observable effect level (NOEL). Therefore, the study demonstrating the lowest observable effect level (LOEL) for nickel in drinking water has been used to arrive at a non-stochastic risk estimate.

In the study of Schroeder and Mitchener adverse effects in rats were demonstrated at a level of 5 ppm in drinking water. Three generations of rats were continuously exposed to 5 ppm of nickel in drinking water. In each of the generations, increased numbers of runts and enhanced neonatal mortality were seen. A significant reduction in litter size and a reduced proportion of males in the third generation also were observed.

To adapt the LOEL into an Acceptable Daily Intake (ADI) for man, the LOEL is divided by an uncertainty factor of 100, as detailed in a recent National Academy of Sciences report and adopted by the U.S. Environmental Protection Agency (Fed. Register 44(52):15980, March 15, 1979). The choice of this factor is based on the absence of long-term or acute human data, scanty results on experimental animals, and an absence of evidence for carcinogenicity.

When the uncertainty factor of 100 is applied to 5 ppm, the lowest level at which adverse effects may occur is then 0.05 ppm. It can be concluded that levels in water below this concentration would not result in adverse health effects.

Nitrobenzene

Criteria Summary

Freshwater Aquatic Life. For nitrobenzene the criterion to protect freshwater aquatic life as derived using the Guidelines is 480 μg/1 as a 24-hour average and the concentration should not exceed 1,100 μg/1 at any time.

Saltwater Aquatic Life. For nitrobenzene the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 53 μg/l as a 24-hour average and the concentration should not exceed 120 μg/ l at any time.

Human Health. For the prevention of adverse effects due to the organoleptic properties of nitrobenzene in water, the criterion is 30 μg/l.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of nitrobenzene is the Final Acute Value of 1,100 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For nitrobenzene the criterion to protect freshwater aquatic life as derived using the Guidelines is 480 μg/l as a 24-hour average and the concentration should not exceed 1,100 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 6,000 μg/l
Final Invertebrate Acute Value = 1,100 μg/l
Final Acute Value = 1,100 μg/l
Final Fish Chronic Value = greater than 2,400 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 43,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = greater than 2,400 μg/l
0.44 × Final Acute Value = 480 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for nitrobenzene using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available.

Results obtained with nitrobenzene and freshwater organisms indicate how a criterion may be estimated.

For nitrobenzene and freshwater organisms 0.44 times the Final Acute Value is less than the Final Chronic Value which is derived from an embryo-larval test with the fathead minnow. Therefore, it seems reasonable to estimate a criterion for nitrobenzene and saltwater organisms using 0.44 times the Final Acute Value.

The maximum concentration of nitrobenzene is the Final Acute Value of 120 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For nitrobenzene the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 53 μg/l as a 24-hour average and the concentration should not exceed 120 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 8,700 μg/l
Final Invertebrate Acute Value = 120 μg/l
Final Acute Value = 120 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 9,700 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 9,700 μg/l
0.44 × Final Acute Value = 53 μg/l

Human Health. There is no established criterion for nitrobenzene in water. Because there are little or no data available on the toxicity of nitrobenzene ingested in drinking water, or on the teratogenic, mutagenic, or carcinogenic effects of nitrobenzene in general, experimental testing is necessary before an oral ingestion based criterion can be derived. It is recommended that testing in these areas of toxicity be implemented so that the effects of nitrobenzene on mammals may be better understood.

Using the methodology of Stokinger and Woodward (1958) [1] a water quality criteria (WQC) is derived using the organoleptic level and the TLV.

Organoleptic Level: minimum detectable odor level in water is 0.03 μg/l = 30 μg/l.

Assuming a daily intake of 2 liters of water, the total intake of nitrobenzene based on this criteria would be 60 micrograms/day. Recommended WQC = 30 μg/l.

A calculation of the percentage of exposure attributable to fish and shellfish products is not applicable to a criterion based upon organoleptic effects. Since an organoleptic effect is not based on a toxicological assessment, it would be inappropriate to apportion a percentage of exposure to the consumption of toxiciologically contaminated fish.

TLV: TLV = 5 mg/m³; air intake = 10 m³/day; assume 80 percent absorption:
(5 mg/m³) x (10 m³/day) x (0.8) = 40 mg/day
average over seven days:
40 mg/day x 5/7 = 29 mg/day

Assuming 100 percent gastrointestinal absorption of nitrobenzene and consuming 2 liters of water daily and 18.7 grams of contaminated fish having a bioconcentration factor of 4.3, would result in a maximum permissible concentration of 13.9 mg/l for the ingested water:

$$\frac{29 \text{ mg/day}}{2 \text{ liter} + (4.3 \times 0.0187) \times 1.0} = 13.9 \text{ mg/l}$$

WQC using TLV = 13.9 mg/l

Since the WQC using TLV is well above the detectable odor level of nitrobenzene, water containing this concentration of nitrobenzene would not be esthetically acceptable for drinking. Even though the limitations of using organoleptic data as a basis for establishing a WQC are recognized, it is recommended that a WQC of 30 μg/l be established at the present time. This level may be altered as more data are developed upon which to calculate a WQC.

The analysis and recommendations generated in this document are based on

[1] Stokinger, H. E., and R. L. Woodward. 1958. Toxicological methods for establishing drinking water standards. Jour. Am. Water Works Assoc. 517.

the literature available to date. If future reports indicate that nitrobenzene may be carcinogenic, mutagenic or teratogenic, a reassessment of the WQC will be necessary.

Nitrophenols

Criteria Summary

Freshwater Aquatic Life. For 2-nitrophenol the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 2,700 μg/l as a 24-hour average and the concentration should not exceed 6,200 μg/l at any time.

For 4-nitrophenol the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 240 μg/l as a 24-hour average and the concentration should not exceed 550 μg/l at any time.

For 2,4-dinitrophenol the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 79 μg/l as a 24-hour average and the concentration should not exceed 180 μg/l at any time.

For 2,4-dinitro-6-methylphenol the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 57 μg/l as a 24-hour average and the concentration should not exceed 130 μg/l at any time.

For 2,4,6-trinitrophenol the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 1,500 μg/l as a 24-hour average and the concentration should not exceed 3,400 μg/l at any time.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for 2-nitrophenol can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

For 4-nitrophenol the criterion to protect saltwater aquatic life as derived using the Guidelines is 53 μg/l as a 24-hour average and the concentration should not exceed 120 μg/l at any time.

For 2,4-nitrophenol the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 37 μg/l as a 24-hour average and the concentration should not exceed 84 μg/l at any time.

For saltwater aquatic life, no criterion for 2,4-dinitro-6-methylphenol can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

For 2,4,6,-trinitrophenol the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 150 μg/l as a 24-hour average and the concentration should not exceed 340 μg/l at any time.

Human Health. To protect human health from the adverse effects of various nitrophenols ingested in contaminated water and fish, suggested criteria are as follows:

Mononitrophenols—no criterion
Dinitrophenols—68.6 μg/l
Trinitrophenols—10 μg/l
Dinitrocresols—12.8 μg/l

Basis for the Criteria

Freshwater Aquatic Life. For 4-nitrophenol and saltwater organisms 0.44 times the Final Acute Value is less than the Final Chronic Value which is derived from results of an embryo-larval test with the sheepshead minnow. Therefore, it seems reasonable to estimate criteria for nitrophenols and freshwater organisms using 0.44 times the Final Acute Value.

2-nitrophenol

The maximum concentration of 2-nitrophenol is the Final Acute Value of 6,200 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 2-nitrophenol the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 2,700 μg/l as a 24-hour average and the concentration should not exceed 6,200 μg/l at any time.

4-nitrophenol

The maximum concentration of 4-nitrophenol is the Final Acute Value of 550 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 4-nitrophenol the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 240 μg/l as a 24-hour average and the concentration should not exceed 550 μg/l at any time.

2,4-dinitrophenol

The maximum concentration of 2,4-dinitrophenol is the Final Acute Value of 180 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 2,4-dinitrophenol the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 79 μg/l as a 24-hour average and the concentration should not exceed 180 μg/l at any time.

2,4-dinitro-6-methylphenol

The maximum concentration of 2,4-dinitro-6-methylphenol is the Final Acute Value of 130 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 2,4-dinitro-6-methylphenol the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 57 μg/l as a 24-hour average and the concentration should not exceed 130 μg/l at any time.

2,4,6-trinitrophenol

The maximum concentration of 2,4,6-trinitrophenol is the Final Acute Value of 3,400 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 2,4,6-trinitrophenol the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 1,500 μg/l as a 24-hour average and the concentration should not exceed 3,400 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

2-nitrophenol

Final Fish Acute Value = 6,200 μg/l
Final Invertebrate Acute Value = not available
Final Acute Value = 6,200 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 35,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 35,000 μg/l
0.44 × Final Acute Value = 2,700 μg/l

4-nitrophenol

Final Fish Acute Value = 4,200 μg/l
Final Invertebrate Acute Value = 550 μg/l
Final Acute Value = 550 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 4,900 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 4,900 μg/l
0.44 × Final Acute Value = 240 μg/l

2,4-dinitrophenol

Final Fish Acute Value = 610 μg/l
Final Invertebrate Acute Value = 180 μg/l
Final Acute Value = 180 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 1,500 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 1,500 μg/l
0.44 × Final Acute Value = 79 μg/l

2,4-dinitro-6-methylphenol

Final Fish Acute Value = 130 μg/l
Final Invertebrate Acute Value = 130 μg/l
Final Acute Value = 130 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 50,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 50,000 μg/l
0.44 × Final Acute Value = 57 μg/l

2,4,6-trinitrophenol

Final Fish Acute Value = 23,000 μg/l
Final Invertebrate Acute Value = 3,400 μg/l
Final Acute Value = 3,400 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 62,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 62,000 μg/l
0.44 × Final Acute Value = 1,500 μg/l

Saltwater Aquatic Life. For 4-nitrophenol and saltwater organisms 0.44 times the Final Acute Value is less than the Final Chronic Value which is derived from results of an embryo-larval test with the sheepshead minnow. Therefore, it seems reasonable to estimate criteria for other nitrophenols and saltwater organisms using 0.44 times the Final Acute Value.

4-nitrophenol

The maximum concentration of 4-nitrophenol is the Final Acute Value of 120 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 4-nitrophenol the criterion to protect saltwater aquatic life as derived using the Guidelines is 53 μg/l as a 24-hour average and the concentration should not exceed 120 μg/l at any time.

2,4-dinitrophenol

The maximum concentration of 2,4-dinitrophenol is the Final Acute Value of 84 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 2,4-dinitrophenol the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 37 μg/l as a 24-hour average and the concentration should not exceed 84 μg/l at any time.

2,4,6-trinitrophenol

The maximum concentration of 2,4,6-trinitrophenol is the Final Acute Value of 340 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For 2,4,6-trinitrophenol the criterion to protect saltwater aquatic life as derived using procedures other than the Guidelines is 150 μg/l as a 24-hour average and the concentration should not exceed 340 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

4-nitrophenol

Final Fish Acute Value = 4,000 μg/l
Final Invertebrate Acute Value = 120 μg/l
Final Acute Value = 120 μg/l
Final Fish Chronic Value = 940 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 7,400 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 940 μg/l
0.44 x Final Acute Value = 53 μg/l

2,4-dinitrophenol

Final Fish Acute Value = 1,900 μg/l
Final Invertebrate Acute Value = 84 μg/l
Final Acute Value = 84 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 93,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 93,000 μg/l
0.44 x Final Acute Value = 37 μg/l

2,4,6-trinitrophenol

Final Fish Acute Value = 20,000 μg/l
Final Invertebrate Acute Value = 340 μg/l
Final Acute Value = 340 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 63,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Fish Chronic Value = 63,000 μg/l
0.44 x Final Acute Value = 150 μg/l

Human Health

Mononitrophenols—no criterion
Dinitrophenols—68.6 μg/l
Trinitrophenols—10 μg/l
Dinitrocresols—12.8 μg/l

Uncertainty factors used for criteria formulation have been loosely adapted from Drinking Water and Health (Natl. Acad. Sci., 1977).[1]

In the absence of data on chronic mammalian effects no water criteria for human health can be established for the mononitrophenol isomers at this time.

Information on the dinitrophenol isomers is limited to 2,4-dinitrophenol. Spencer, et al. (1948),[2] in a six-month feeding study with rats demonstrated the no-observable-effect level (NOEL) for 2,4-dinitrophenol to be between 5.4 mg/kg and 20 mg/kg. Taking the lower of the two figures and assuming a 70 kg man consumes 2 liters of water daily and 18.7 grams of contaminated fish having a BCF of 2.4, the NOEL for humans based on the results obtained in rats may be calculated as follows:

$$\frac{5.4 \text{ mg/kg} \times 70 \text{ kg} = 378 \text{ mg}}{2 \text{ liters} + (2.4 \times 0.0187) \times 1.0} = 185.3 \text{ mg/l}$$

Based on these calculations no biological effect would be predicted in a man drinking water containing 185.3 mg/l 2,4-DNP.

Experience with the use of 2,4-DNP as an anti-obesity drug in the 1930's indicates that adverse effects, including cataract formation, may occur in humans exposed to as little as 2 mg/kg/day. The drug was frequently used in an uncontrolled manner and the available data do not allow the calculation of a no-adverse-effect level in humans. It is clear, however, that ingestion of 2 mg/kg/day 2,4-DNP for a protracted period may result in adverse effects, including cataracts, in a small proportion of the population. Assuming a 70 kg man consumes 2 liters of water daily and 18.7 grams of contaminated fish having a BCF of 2.4 and assuming 100 percent gastrointestinal absorption of 2,4-DNP, a 2 mg/kg dose of 2,4-DNP would result if drinking water contained 68.6 mg/l of 2,4-DNP.

$$\frac{140 \text{ mg/day}}{2 \text{ liters} + (2.4 \times 0.0187) \times 1.0} = 68.6$$

These data taken together with the demonstrated bacterial mutagenicity of 2,4-DNP (Demerec, et al. 1951) [3] and the suspected ability of the compound to induce chromosomal breaks in

[1] National Academy of Sciences. 1977. Drinking water and health. Washington, D.C.

[2] Spencer, H.C., et al. 1948. Toxicological studies on laboratory animals of certain alkyl dinitrophenols used in agriculture. Jour. Ind. Hyg. Toxicol. 30: 10.

[3] Demerec, M., et al. 1951. A survey of chemicals for mutagenic action on *E. coli*. The Am. Natur. 85: 119.

mammals (Mitra and Manna, 1971) [4] suggest that an uncertainty factor of 1,000 should be used in criteria formulation.

The suggested water criterion for 2,4-DNP is, therefore:

$$\frac{68.6 \text{ mg/l}}{1{,}000} = 68.6 \ \mu\text{g/l}$$

The available data are insufficient to enable calculation of water criterion levels for the remaining dinitrophenol isomers. For the present, it seems reasonable to assume that the 2,4-dinitrophenol criterion would be appropriate for the other isomers.

Chronic mammalian toxicology data for the trinitrophenols are absent from the literature. An outbreak of microscopic hematuria among shipboard U.S. Navy personnel exposed to 2,4,6-trinitrophenol in drinking water has been reported, however. Although it is not possible to precisely estimate either the 2,4,6-trinitrophenol water level or duration of exposure required for the development of hematuria 2,4,6-trinitrophenol levels of 10 mg/l and 20 mg/l were detected in drinking water aboard two ships at the time of the outbreak.

Based on the presumed development of hematuria in humans at drinking water levels of 10 mg/l and the evidence indicating mutagenic activity in bacteria, an uncertainty factor of 1,000 is suggested for formulation of the 2,4,6-trinitrophenol water criteria:

$$\frac{10 \text{ mg/l}}{1{,}000} = 10 \ \mu\text{g/l}$$

Since available data are insufficient to enable calculation of water criterion levels for the remaining trinitrophenol isomers, it seems reasonable to asume, for the present, that the 2,4,6-trinitrophenol criterion is appropriate for the other isomers.

Although 4,6-dinitro-o-cresol (DNOC) is considered a cumulative poison in humans, probably as a result of slow metabolism and inefficient excretion, true chronic or subacute effects have never been reported in either humans or experimental animals. Since DNOC is not a cumulative poison in experimental animals, extrapolation to humans from long-term animal studies is of questionable value.

The no-observable-effect level (NOEL) for DNOC respiratory exposure in humans has been reported as 0.2 mg/m^3 air (Natl. Inst. Occup. Safety Health, 1978).[5] NIOSH (1978) has, in fact, recommended that the current Federal workplace environmental limit of 0.2 mg/m^3 be retained, based on the available data.

It is possible to calculate the anticipated daily exposure of a 70 kg human male exposed to 0.2 mg/m^3 for an eight-hour period. If one assumes the average minute volume is 28.6 liters of air/minute (average minute volume for a man doing light work—NIOSH, 1978) [5] the anticipated daily exposure is 39 μg/kg/day. Since the NOEL's calculated from long-term experimental animal studies are considerably higher than this value, it will be used as a basis for the suggested water criterion.

If one assumes that absorption of DNOC across the respiratory tract is identical to gastrointestinal absorption, and that a 70 kg human male consumes 2 liters of water daily and 18.7 g of contaminated fish having a BCF of 7.5, the following calculations indicate the maximum allowable levels of DNOC in drinking water based on the NIOSH air standard values:

$$39 \ \mu\text{g/kg/day} \times 70 \text{ kg} = 2.73 \text{ mg/day}$$

$$\frac{2.73 \text{ mg/day}}{(2/1 + (7.5 \times 0.0187) \times 1.0} = 1.28 \text{ mg/l}$$

In view of the lack of data indicating chronic effects and the existence of a very recent Federal guideline for human exposure, an uncertainty factor of 100 is chosen for the protection of the general public. The suggested criterion for 4,6-dinitro-o-cresol (and in the absence of adequate data, the other dinitrocresol isomers) is

$$\frac{1.28 \text{ mg/l}}{100} = 12.8 \ \mu\text{g/l}$$

Phenol

Criteria Summary

Freshwater Aquatic Life. For phenol the criterion to protect freshwater aquatic life as derived using the Guidelines is 600 μg/l as 24-hour average, and the concentration should not exceed 3,400 μg/l at any time.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for phenol can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. For the protection of human health from phenol ingested through water and through contaminated aquatic organisms the concentration in water should not exceed 3.4 mg/l.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of phenol is the Final Acute Value of 3,400 μg/l and the 2.4 hour average concentration is the Final Chronic Value of 600 μg/l. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For phenol the criterion to protect freshwater aquatic life as derived using the Guidelines is 600 μg/l as a 24-hour average, and the concentration should not exceed 3,400 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 4,000 μg/l
Final Invertebrate Acute Value = 3,400 μg/l
Final Acute Value = 3,400 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = 600 μg/l
Final Plant Value = 20,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 600 μg/l
0.44 × Final Acute Value = 1,500 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for phenol using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 620 μg/l
Final Invertebrate Acute Value = 960 μg/l
Final Acute Value = 620 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = not available
0.44 × Final Acute Value = 270 μg/l

Human health. Heller and Pursell (1938) reported no significant effects in a multi-generation feeding study in rats at 100, 500, and 1000 mg/l of phenol in drinking water for five generations and at 3000 and 5000 mg/l for three generations. Assuming a daily water intake of 30 ml and an average bodyweight of 300 grams, these rats would have received daily doses of 10, 50, 100, 300, and 500 mg/kg/day. The upper range approaches a single LD_{50} dose per day. Deichmann and Oesper (1940) reported no significant effects in

[4] Mitra, A. B., and G. K. Manna. 1971. Effect of some phenolic compounds on chromosomes of bone marrow cells of mice. Indian Jour. Med. Res. 59: 1442.

[5] National Institute for Occupational Safety and Health. 1978. Criteria for a recommended standard: Occupational exposure to dinitro-ortho-cresol. Dept. of Health, Education, and Welfare, Washington, D.C.

rats receiving approximately 70, 100, or 163 mg/kg/day in their drinking water for 12 months. However, both of these studies did not report detailed pathological or biochemical studies but relied mostly on the weights and the general appearance of the animals for evaluation. In a more recent study (Dow Chemical Co., 1976), 135 dosings by gavage over six months at 100 mg/kg/dose resulted in some liver and kidney damage. At 50 mg/kg/dose the exposure resulted in only slight kidney damage. It must be borne in mind that in the first two studies the phenol is incorporated into the drinking water so that the daily dose is taken gradually. In the Dow study the phenol is administered in a single slug. A 500-fold uncertainty factor applied to the 50 mg/kg exposure in the Dow study would provide an estimated acceptable level of 0.1 mg/kg/day for man. In the case of phenol a great deal of information on human exposure exists. Long term animal data are available as well, however, the detail in these studies is very incomplete. Shorter term studies of sufficient detail provide the lowest dose level in animal studies for which an adverse effect was seen. It was judged that the existing data did not fully satisfy the requirements for the use of a 100X uncertainty factor but were better than the requirements for a 1000X uncertainty factor (Table 9). Consequently, an intermediate 500X uncertainty factor was selected.

Table 9.—*Guidelines for Using Uncertainty Factors*

(NAS Drinking Water and Human Health, 1977)

Uncertainty Factor = 10	Valid experimental results from studies on prolonged ingestion by man, with no indication of carcinogenicity.
Uncertainty Factor = 100	Experimental results of studies of human ingestion not available or scanty (e.g., acute exposure only.) Valid results of long-term feeding studies on experimental animals or in the absence of human studies, valid animal studies on one or more species. No indication of carcinogenicity.
Uncertainty Factor = 1,000	No long term or acute human data. Scanty results on experimental animals. No indication of carcinogenicity.

When one examines the amount of phenol absorbed through inhalation near the TLV of 20 mg/m³ for occupational exposures by using the Stokinger and Woodward model (1958), then at a breathing rate of 10 m³ for an eight hour day with 75 percent absorption and a body weight of 70 kg, a man would absorb approximately 2.14 mg/kg/working day, assuming no skin absorption. The use of the Stokinger-Woodward model may be applicable to estimate acceptable intake from water.

It has been established that phenol is absorbed rapidly by all routes and subsequently is distributed rapidly. If a ten-fold safety factor is applied to the projected doses absorbed from inhalation at the TLV (which already incorporates some safety factors), then the projected acceptable level would be 0.2 mg/kg/day. The estimate from animal data is 0.1 mg/kg/day. On the basis of chronic toxicity data in animals and man, an estimated acceptable daily intake for phenol in man should be 0.1 mg/kg/day or 7.0 mg/man, assuming a 70 kg body weight. Therefore, consumption of 2 liters of water daily and 18.7 grams of contaminated fish having a bioconcentration factor of 2.3, would result in assuming 100% gastrointestinal absorption of phenol, a maximum permissible concentration of 3.4 mg/l for the ingested water:

$$\frac{7.0 \text{ mg/day}}{(2 \text{ liters} + (2.3 \times 0.0187) \times 1.0} = 3.4 \text{ mg/l}$$

This water quality criterion is in the range of reported taste and odor threshold values for phenol which have been reported. It is recognized that when ambient water containing this concentration of phenol is chlorinated, various chlorinated phenols may be produced in sufficient quantities to produce objectional taste and odors. However, the ambient water quality criterion for phenol is based on phenol alone. For the criteria of 2-chlorophenol, 2,4-dichlorophenol and other chlorophenols, reference should be made to their specific criterion documents.

Phthalate Esters

Criteria Summary

Freshwater Aquatic Life. For freshwater aquatic life, no criterion for any phthalate ester can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for any phthalate ester can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. For the protection of human health from the toxic properties of phthalate esters ingested through water and through contaminated aquatic organisms, the ambient water criteria for dimethyl phthalate and diethyl phthalate are determined to be 160 mg/l and 60 mg/l, respectively. The water quality criteria for dibutyl phthalate and di-2-ethylhexyl phthalate are determined to be 5 mg/l and 10 mg/l, respectively.

Basis for the Criteria

Freshwater Aquatic Life. No freshwater criterion can be derived for any phthalate ester using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data. All concentrations below have been rounded to two significant figures.

butylbenzyl phyhalate

Final Fish Acute Value = 6,100 μg/l
Final Invertebrate Acute Value = 3,700 μg/l
Final Acute Value = 3,700 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 110 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 110 μg/l
0.44 × Final Acute Value = 1,600 μg/l

diethyl phthalate

Final Fish Acute Value = 14,000 μg/l
Final Invertebrate Acute Value = 2,100 μg/l
Final Acute Value = 2,100 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 86,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 86,000 μg/l
0.44 × Final Acute Value = 920 μg/l

dimethyl phthalate

Final Fish Acute Value = 6,900 μg/l
Final Invertebrate Acute Value = 1,300 μg/l
Final Acute Value = 1,300 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 39,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 39,000 μg/l
0.44 × Final Acute Value = 570 μg/l

di-n-butyl phthalate

Final Fish Acute Value = 310 μg/l
Final Invertebrate Acute Value = 36 μg/l
Final Acute Value = 36 μg/l

Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = not available
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = not available
0.44 × Final Acute Value = 16 μg/l

di-2-ethylhexylphthalate

Final Fish Acute Value = not available
Final Invertebrate Acute Value = 450 μg/l
Final Acute Value = 450 μg/l
Final Fish Chronic Value = 0.63 μg/l
Final Invertebrate Chronic Value = less than 0.59 μg/l
Final Plant Value = not available
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = less than 0.59 μg/l
0.44 × Final Acute Value = 200 μg/l

Saltwater Aquatic Life. No saltwater criterion can be derived for any phthalate ester using the Guidelines because no Final Chronic Value for either fish invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data.

butylbenzyl phthalate

Final Fish Acute Value = 66,000 μg/l
Final Invertebrate Acute Value = 170 μg/l
Final Acute Value = 170 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 170 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 170 μg/l
0.44 × Final Acute Value = 75 μg/l

diethyl phthalate

Final Fish Acute Value = 4,400 μg/l
Final Invertebrate Acute Value = 130 μg/l
Final Acute Value = 130 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 66,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 66,000 μg/l
0.44 × Final Acute Value = 57 μg/l

dimethyl phthalate

Final Fish Acute Value = 8,600 μg/l
Final Invertebrate Acute Value = 1,300 μg/l
Final Acute Value = 1,300 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 26,000 μg/l
Residue Limited Toxicant
Concentration = not available
Final Chronic Value = 26,000 μg/l
0.44 × Final Acute Value = 570 μg/l

Human Health. From the available information, the phthalic acid esters have not been found to be carcinogenic in animals or man. At high doses when injected i.p., the esters can act as teratogenic agents and possibly as mutagenic agents in rats. These esters also have an effect upon gonads in rats. Evidence is also at hand to show that the esters may bring about biochemical and pathological changes in the liver of rats when repeatedly administered orally or by i.p. When solubilized in blood components, DEHP has demonstrated liver involvement when these products have been repeatedly administered i.v. to monkeys. Inhalation studies in rats and man suggest that certain phthalates may be responsible for neurological disorders, but these results need further verification since other non-phthalate esters may also have been present leading to the problems.

Since a number of phthalate esters are in the environment or may be present in water, it was thought appropriate to review chronic toxicity data for those esters in which well established chronic toxicity data were reported to establish an "allowable daily intake" (ADI). In calculating the ADI, an uncertainty factor of 100 was used based upon a 70 kg person. Table 11 taken from Shibko (1974), lists eight esters in which the "no effect" dose was established from chronic toxicity studies in rats or dogs. The table also includes the number of days the animals were fed the specific phthalate esters and the calculated ADI. It will be noted that the ADI ranged from a low of 9.8 mg/day for dicyclohexyl phthalate to a high of 700 mg/day for dimethyl phthalate.

For the sake of establishing water quality criteria, it is assumed that on the average a person ingests 2 liters of water and 18.7 grams of fish. The amount of water ingested is approximately 100 times greater than the amount of fish consumed. Since fish may biomagnify the esters to various degrees, a "biomagnification factor" (F) is used in the calculation. Biomagnification factors for dimethyl, diethyl, dibutyl and di-2-ethylhexyl esters were derived by the EPA ecological laboratories, Duluth (see Ingestion from Foods).

Table 11.—*Calculated Allowable Daily Intake in Water and Fish for Various Phthalate Esters*

Ester	No effect dose[1] (mg/kg/day)	Species	Days	ADI[2] (mg/day)	F[3]	Recommended criteria mg/l
1. Dimethyl	1000	Rat	104	700.0	130	160
2. Diethyl	625	Dog	52	438.0	270	60
3. Dibutyl	18	Dog	52	12.6	26	5
4.Dicyclohexyl	14	Dog	52	9.8	(4)	
5. Methyl phthalyl ethyl glycolate	750	Rat	104	525.0	(4)	
6. Ethyl phthalyl ethyl glycolate	250	Rat	104	175.0	(4)	
7. Butyl phthalyl ethyl glycolate	140	Dog	104	98.0	(4)	
8. Di-2-ethyhexyl	60	Dog	52	42.0	95	10

[1] From: Shibko, 1974.
[2] Allowable Daily Intake for 70 kg person (100 safety factor).
[3] F = Biomagnification factor.
[4] Not established.

Due to lack of data, bioconcentration factors could not be derived for dicyclohexyl, methyl phthalyl ethyl glycolate, ethyl phthalyl ethyl glycolate and butyl phthalyl ethyl glycolate.

The equation for calculating an acceptable amount of ester in water based on ingestion of 2 liters of water and 18.7 g fish is:

$$(2/l)\,X + (0.0187 \times F)\,X = ADI$$

where 2/l = 2 liters of drinking water consumed
0.0187 kg = amount of fish consumed daily
F = biomagnification factor
ADI = Allowable Daily Intake (mg/day for 70 kg person)

For example, consider that the ADI for dimethyl phthalate is 700 mg/day and the biomagnification factor is 130, the above equation can be solved as follows:

$$2X + (0.0187 \times 130)X = 700$$
$$2X + (2.43)X = 700$$
$$4.43X = 700$$
$$X = 158 \text{ (or } \approx 160 \text{ mg/l)}$$

Thus, the recommended water quality criterion is 160 mg/l.

Similar calculations were made for each of the esters and are presented below:

Diethyl

$$2/lX + (0.0187 \times 270)X = 438$$
$$2X + 5.05X = 438$$
$$7.05X = 438$$
$$X = 62 \text{ mg/l (or } \approx 60 \text{ mg/l)}$$

Dibutyl

$$2/lX + (.0187 \times 26) = 12.6$$
$$2X + .468X = 12.6$$
$$2.468X = 12.6$$
$$X = 5.10 \text{ mg/l (or } \approx 5 \text{ mg/l)}$$

Di-2-ethyhexyl

$2/1X + (.0187 \times 95) = 42$
$2/1 + 1.7765 = 42$
$3.7765X = 42$
$X = 11.12$ mg/l (or ≈ 10 mg/l)

Thus, the recommended water quality criteria for four phthalate esters are:

dimethyl, 160 mg/l
diethyl, 60 mg/l
dibutyl, 5 mg/l
di-2-ethyhexyl, 10 mg/l
(see Table 11).

It seems clear that exposure from the water route presents no real risk to the population in regard to the phthalate esters. Reported levels of phthalate esters in U.S. surface waters have only been in the ppb range; at approximately 1 to 2 μg/l (see Ingestion from Water section).

Other routes of exposure such as inhalation (industrial sites manufacturing the esters), dermal exposure, consumption of certain fatty or fatty-like foods and certain fish will be the major contributors to the body-load of phthalate esters. Phthalate ester residues in foods such as margarine, cheese and milk may, on some occasions, reach 50 ppm. Also a special group at risk will be patients to whom chronic transfusions of blood and blood products are administered.

Although it is recognized that routes of exposure other than water contribute more to the body burden of phthalate esters, this information will not be considered in forming ambient water quality criteria until additional analysis can be made. Therefore, the criteria presented assumed a risk estimate based only on ambient water exposure.

The need for more accurate residue content of foods, fish and water is still very apparent and, as more data become available, a reevaluation should be made as to the possible hazard to the population by the ingestion of phthalate esters.

Polychlorinated Biphenyls

Criteria Summary

Freshwater Aquatic Life. For polychlorinated biphenyls the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.0015 μg/l as a 24-hour average and the concentration should not exceed 6.2 μg/l at any time.

Saltwater Aquatic Life. For polychlorinated biphenyls the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.024 μg/l as a 24-hour average and the concentration should not exceed 0.20 μg/l at any time.

Human Health. For the maximum protection of human health from the potential carcinogenic effects of exposure to chloroform through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of chloroform estimated to result in additional lifetime cancer risks ranging from no additional risk to an additional risk of 1 in 100,000 are presented in the Criterion Formulation section of this document. The Agency is considering setting criteria at an interim target risk level in the range of 10^{-5}, 10^{-6}, or 10^{-7} with corresponding criteria of 0.2 ng/l, 0.02 ng/l and 0.002 ng/l respectively.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of polychlorinated biphenyls is the Final Acute Value of 6.2 μg/l and the 24-hour average concentration is the Final Chronic Value of 0.0015 μg/l. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For polychlorinated biphenyls the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.0015 μg/l as a 24-hour average and the concentrations should not exceed 6.2 μg/l at any time.

Summary of Available Data

Final Fish Acute Value + 7.7 μg/l
Final Invertebrate Acute Value = 6.2 μg/l
Final Acute Value = 6.2 μg/l
Final Fish Chronic Value = 0.20 μg/l
Final Invertebrate Chronic Value = 0.73 μg/l
Final Plant Value = 0.10 μg/l
Residue Limited Toxicant
Concentration = 0.0015 μg/l
Final Chronic Value = 0.0015 μg/l
0.44 x Final Acute Value = 2.7 μg/l

Saltwater Aquatic Life. The maximum concentration of polychlorinated biphenyls is the Final Acute Value of 0.20 μg/l and the 24-hour average concentration is the Final Chronic Value of 0.024 μg/l. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For polychlorinated biphenyls the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.024 μg/l as a 24-hour average and the concentration should not exceed 0.20 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = not available
Final Invertebrate Acute Value = 0.20 μg/l
Final Acute Value = 0.20 μg/l
Final Fish Chronic Value = 0.049 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 0.1 μg/l
Residue Limited Toxicant
Concentration = 0.024 μg/l
Final Chronic Value = 0.024 μg/l
0.44 x Final Acute Value = 0.087 μg/l

Human Health. An assessment of carcinogenic risk will be made by extrapolation from animal data using a linear (non-threshold) model. The model used takes into account the bioaccumulation of PCBs in fish and shellfish. It is assumed that an average of 2 liters/day of water are consumed along with 18.7 g of fish taken from that water source. Exposures from other food sources, air or occupational exposure are not included in the risk assessment.

Among the studies reviewed by this document, only one appears suitable for use in the cancer risk assessment. None of the mouse studies involved feeding for most or all of a lifetime and are therefore unsuitable. Of the rat studies, the only one involving long term exposure and adequate numbers of animals is the study in Sherman rats by Kimbrough, et al. (1975)[1].

This study has some drawbacks in that it lacks any evidence of a dose-response (due to the use of only one dose level), it tests only one sex of the species, and only one commercial mixture of PCBs was tested. Yet the experimental design is a good one in many ways: the treatment was given over a good proportion of the lifespan, there was an appropriate route (food) and distribution of exposure (uniform dose over time), the authors provided good documentation of the actual intake dose, a sufficiently large number of experimental and control animals were used to detect a statistically significant increase in tumors and there was a thorough and well documented description of the pathology (hepatocellular carcinoma). The NCI study (1978)[2] was the only other study involving a long term exposure and was suggestive of a carcinogenic effect; however, the lack of an adequate number of animals renders it unsuitable as a study upon which to base an estimate of carcinogenic risk.

Under the Consent Decree in *NRDC vs. Train*, criteria are to state "recommended maximum permissible concentrations (including where

[1] Kimbrough, R. D., et al. 1975. Induction of liver tumors in Sherman strain female rats by polychlorinated biphenyl Aroclor 1260. Jour. Natl. Cancer Inst. 55: 1453.

[2] National Cancer Institute. 1978. Bioassay of Aroclor 1254 for possible carcinogenicity. Carcinogenesis Technical Report Series No. 38, DHEW Publ. No. (NIH) 78-838, 62 pp.

appropriate, zero) consistent with the protection of aquatic organisms, human health, and recreational activities." PCBs are suspected of being human carcinogens. Because there is no recognized safe concentration for a human carcinogen, the recommended concentration of PCBs in water for maximum protection of human health is zero.

Because attaining a zero concentration level may be infeasible in some cases and in order to assist the Agency and States in the possible future development of water quality regulations, the concentration of PCBs corresponding to several incremental lifetime cancer risk levels have been estimated. A cancer risk level provides an estimate of the additional incidence of cancer that may be expected in an exposed population. A risk of 10^{-5} for example, indicates a probability of one additional case of cancer for every 100,000 people exposed, a risk of 10^{-6} indicates one additional case of cancer for every million people exposed, and so forth.

In the **Federal Register** notice of availability of draft ambient water quality criteria, EPA stated that it is considering setting criteria at an interim target risk level of 10^{-5}, 10^{-6} or 10^{-7} as shown in the table below.

Exposure assumptions (per day)	Risk levels and corresponding criteria[1]			
	0	10^{-7}	10^{-6}	10^{-5}
2 liters of drinking water and consumption of 18.7 grams fish and shellfish[2].	0	0.002 ng/l	0.02 ng/l	0.2 ng/l
Consumption of fish and shellfish only..	0	0.002 ng/l	0.02 ng/l	0.2 ng/l

[1] Calculated by applying a modified "one-hit" extrapolation model described in FR 15926, 1979. Since the extrapolation model is linear at low doses, the additional lifetime risk is directly proportional to the water concentration. Therefore, water concentrations corresponding to other risk levels can be derived by multiplying or dividing one of the risk levels and corresponding water concentrations shown in the table by factors such as 10, 100, 1,000, and so forth.

[2] Approximately 99.8 percent of the PCB exposure results from the consumption of aquatic organisms which exhibit an average bioconcentration potential of 46,000 fold. The remaining 0.2 percent of PCB exposure results from drinking water.

Concentration levels were derived assuming a lifetime exposure to various amounts of PCBs, (1) occurring from the consumption of both drinking water and aquatic life grown in waters containing the corresponding PCB's concentrations and, (2) occurring solely from consumption of aquatic life grown in the waters containing the corresponding PCB concentrations. Although total exposure information for PCBs is discussed and an estimate of the contributions from other sources of exposure can be made, this data will not be factored into ambient water quality criteria formulation until additional analysis can be made. The criteria presented, therefore, assume an incremental risk from ambient water exposure only.

The very low limits suggested by this risk estimate are due in large part to the very large bioaccumulation factor in fish (46,000). This figure is an average for a wide variety of saltwater and freshwater organisms (see section on Ingestion from foods).

As possible strategies to reduce human exposures to PCBs are considered, the relative contributions of ingested water and fish should be kept in mind. At the assumed consumption rate of 2l of drinking water and 18.7 g of fish/day, over 99 percent of the dietary PCBs will be obtained from fish. Strategies which focus separately on the reduction of PCB levels in water and fish for human consumption might be more practical and productive than a single standard for water which takes bioaccumulation in fish into account.

A final comment about the risk level derived from this study is that it is based on animal data which are statistically weak. The weight of evidence indicates that PCBs are carcinogenic in rodents. However, the carcinogenic activities of these compounds are not great. An acceptable noncarcinogenic level could be established with greater certainty if better quantitative data on carcinogenicity were available. Studies with larger numbers of animals designed to measure relatively small effects are needed. Also, the rats appears to be much less sensitive to the acute and subacute effects of PBCs than man or non-human primates. Further investigation of the effects of PCBs in Rhesus monkeys, particularly with reference to the gastric lesions produced, would be useful.

Summary of Pertinent Data. The water quality criterion for PCBs is derived from the hepatocellular carcinoma and neoplastic nodule response of Sherman strain female rats fed 100 ppm Aroclor 1260 (Kimbrough, et al., 1975).[1] A time-weighted average dose of 88.4 ppm was administered for approximately 21.5 months and the animals were observed for an additional six weeks before terminal sacrifice. The incidence of hepatocellular carcinoma and neoplastic nodules was 170/184 in the treated group and 1/173 in the control group. Assuming a fish bioaccumulation factor of 46,000, the criterion is calculated from the following parameters:

$n_t = 170$
$N_t = 184$
$n_c = 1$
$N_c = 173$
Le = 730 days
le = 645 days
$d = 88.4 \times 0.05 = 4.42$ mg/kg/day
w = 0.4 kg
L = 730 days
R = 46,000
F = 0.0187 kg/day

Based on these parameters, the one-hit slope B_H is 3.25 $(mg/kg/day)^{-1}$. The resulting water concentration of PCBs calculated to keep the individual lifetime cancer risk below 10^{-5} is 0.24 nanograms per liter.

Toluene

Criteria Summary

Freshwater Aquatic Life. The data base for freshwater aquatic life is insufficient to allow use of the Guidelines. The following recommendation is inferred from toxicity data for saltwater organisms.

For toluene the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 2,300 μg/l as a 24-hour average and the concentration should not exceed 5,200 μg/l at any time.

Saltwater Aquatic Life. For toluene the criterion to protect saltwater aquatic life as derived using the Guidelines is 100 μg/l as a 24-hour average and the concentration should not exceed 230 μg/l at any time.

Human Health. For the protection of human health from the toxic properties of toluene ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 17.4 mg/l.

Basis for the Criteria

Freshwater Aquatic Life. No freshwater criterion can be derived for toluene using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available.

Data for toluene and saltwater organisms can be used to estimate a criterion.

For toluene and saltwater organisms 0.44 times the Final Acute Value is less than the Final Chronic Value derived from results of an embryo-larval test with the sheepshead minnow. Therefore, a reasonable estimate of a criterion for toluene and freshwater organisms would be 0.44 times the Final Acute Value.

The maximum concentration of toluene is the Final Acute Value of 5,200 μg/l and the estimated 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For toluene the criterion to protect freshwater aquatic life as derived using procedures other than the Guidelines is 2,300 μg/l as a 24-hour average and the concentration should not exceed 5,200 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 5,200 μg/l
Final Invertebrate Acute Value = 13,000 μg/l
Final Acute Value = 5,200 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 250,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 250,000 μg/l
0.44 × Final Acute Value = 2,300 μg/l

Saltwater Aquatic Life. The maximum concentration of toluene is the Final Acute Value of 230 μg/l and the 24-hour average concentration is 0.44 times the Final Acute Value. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For toluene the criterion to protect saltwater aquatic life as derived using the Guidelines is 100 μg/l as a 24-hour average and the concentration should not exceed 230 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 2,000 μg/l
Final Invertebrate Acute Value = 230 μg/l
Final Acute Value = 230 μg/l
Final Fish Chronic Value = 320 μg/l
Final Invertebrate Chronic Value = not available
Final Plant Value = 8,000 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 320 μg/l
0.44 × Final Acute Value = 100 μg/l

Human Health

Existing Guidelines and Standards. The only current guideline for toluene exposure has been established to prevent adverse health effects from the chemical in occupational settings. The present standard is 100 ppm (375 mg/m^3), determined as a time-weighted average exposure for an eight hour workday, with a ceiling of 200 ppm (NIOSH, 1973). Skin and eye exposure is to be minimized. This standard was set primarily on the basis of subjective and objective signs of mucus membrane irritiation and deficits in central nervous system function upon acute inhalation exposure of human subjects to 200 ppm toluene. Short-term inhalation of 100 ppm was apparently without demonstrable effect in humans. Reports reviewed by the National Institute for Occupational Safety and Health (1973) also have failed to indicate adverse effects on the hematopoietic, hepatorenal, or other systems of workers routinely inhaling approximately 100 ppm toluene.

A review of potentially harmful effects of chemical contaminants of drinking water was undertaken by the Committee on Safe Drinking Water of the National Academy of Sciences (1977). The recommendations of this committee were to be used by the U.S. EPA as the scientific basis for revision or ratification of the Interim Primary Drinking Water Regulations promulgated under the Safe Drinking Water Act of 1974. Toluene was one of the organic chemicals considered here. Although it was concluded that toluene and its major metabolite, benzoic acid, were relatively non-toxic, the committee felt there was insufficient toxicological data available to serve as a basis for setting a long-term ingestion standard. It was recommended that studies be conducted to produce relevant information (NAS, 1977). Toluene has recently been considered for a second time by a reorganized Toxicology Subcommittee of the Safe Drinking Water Committee of the National Academy of Sciences. Results of the deliberations of this group have not yet been made public.

There are no Federal or State guidelines, nor standards for general atmospheric pollution by toluene.

Current Levels of Exposure. Toluene has been detected in raw water and in finished water supplies of several communities in the United States. Levels of up of 11 μg/l were found in finished water from the New Orleans area (U.S. EPA, 1975a). In a nationwide survey of water supplies from ten cities, six were discovered to be contaminated with toluene (U.S. EPA, 1975b). Concentrations of 0.1 and 0.7 μg/l were measured in two of these water supplies. Toluene was detected in 1 of 111 communities' finished drinking waters during a second nationwide survey (U.S. EPA, 1977). In a subsequent phase of this survey, toluene was found in one raw water and three finished waters out of 11 surveyed (U.S. EPA, 1977). A level of 19 μg/l measured by gas chromatography/mass spectrometry, was found in one of these finished waters, and 0.5 μg/l was found in another.

There is a paucity of data available on levels of toluene in foods. Toluene was detected in fish caught from polluted waters in the proximity of petroleum and petrochemical plants in Japan (Ogata and Miyake, 1973). A concentration of 5 μg/g was measured in the muscle of one such fish. Two major metabolites of toluene, benzaldehyde and benzoic acid, naturally occur in foods or are intentionally added. Benzaldehyde is a flavoring agent, while benzoic acid is a preservative. Benzoic acid is also given in large oral doses to humans as a clinical method for measuring liver function.

Although toluene has been detected in the atmosphere, concentrations are many times lower than vapor levels considered to be potentially harmful in occupational settings. An atmospheric concentration of 39 ppm toluene was measured in Zurich, Switzerland (Grob and Grob, 1971). An average level of 37 ppb toluene was observed in Los Angeles air in 1966 (Lonneman, et al. 1968). The maximum amount detected there was 129 ppb. Comparable levels were found upon evaluation of air in Toronto, Canada (Pilar and Graydon, 1973). The maximum concentration of toluene measured in Toronto was 188 ppb, while the average concentration was 30 ppb. The atmospheric levels of toluene in both Toronto and Los Angeles varied considerably according to the time of day and sampling location (Pilar and Graydon, 1973; Altshuller, et al. 1971). Thus, it appears that atmospheric toluene in urban areas arises primarily from automotive emissions, with solvent losses as a secondary source.

The most significant toluene inhalation exposures occur in occupational and inhalant abuse settings. Occupational exposure levels are generally lower than the current standard of 100 ppm, although short exposures to higher vapor concentrations occur. Purposeful inhalation of toluene vapors in order to inebriate oneself is a quite different situation, since the participant may inhale extremely high concentrations repeatedly for months or years. Toluene

concentrations as high as 20,000 to 30,000 ppm can produce intoxication within minutes under such circumstances.

Special Groups at Risk. At present levels of exposure to toluene in the environment, available toxicological data do not suggest that any group in the general population would be at risk. Exposure to levels of the chemical necessary to produce physiological or toxicological effects would be anticipated primarily in occupational or solvent abuse situations. Environmental contribution of toluene in such settings should be minimal.

Basis and Derivation of Criterion. Although acute exposure to high levels of toluene can result in marked central nervous system depression, this action is rapidly reversible upon cessation of exposure in both laboratory animals (Peterson and Bruckner, 1976) and in man (Longley, et al. 1967). When administered acutely in quite large doses to animals, toluene can alter the metabolism and bioactivity of certain chemicals which are degraded by the mixed function oxidase system. Toluene appears to have little capacity to cause residual tissue injury. There is no conclusive evidence that the parent compound or its metabolites are mutagenic, although they have apparently not been tested in an *in vitro* mutagencity assay (Dean, 1978). Toluene has not been found to be teratogenic in laboratory animals (Roche and Hine, 1968; Hudak and Ungvary, 1978). Toluene has not been demonstrated to be carcinogenic when applied to the skin of mice (Poel, 1963; Doak, et al. 1976) or when administered by inhalation at concentrations of up to 300 ppm for as long as 18 months to male and female rats (Gibson, 1979). There are no accounts in the literature in which cancer in a human population is attributed specifically to toluene.

A number of investigations of the subacute and chronic toxicity of toluene have been carried out. Although the majority of emphasis has been placed upon inhalation exposure, Wolf, et al. (1956) did conduct a long-term, oral dosing study in which female rats were given 118, 354, and 590 mg/kg of toluene in olive oil by stomach tube 5 times weekly for 193 days. No adverse effects on growth, appearance and behavior, mortality, organ/body weights, blood urea nitrogen levels, bone marrow counts, peripheral blood counts, or morphology of major organs were observed at any dose level. The lack of toxicity reported here is supported by findings of other groups of investigators who found no evidence of residual injury in a variety of animal species subjected to toluene vapors for varying times over periods as long as 18 months (Jenkins, et al. 1970; Carpenter, et al. 1976; Bruckner and Peterson, 1978; Rhudy, et al. 1978; Gibson, 1979).

Therefore, it seems reasonable that the highest dose utilized by Wolf, et al. (1956), namely 590 mg/kg, might serve as the basis for calculating an "Acceptable Daily Intake" for toluene. Although 590 mg/kg will be considered here as a "maximum-no-effect" dose, it should be recognized that the actual "maximum-no-effect" dose may be higher, since Wolf, et al. (1956) did not determine a "minimum-toxic-dose." Reynolds and Yee (1968) saw no effect on several parameters of hepatotoxicity in rats given a single oral dose of 2.4 g/kg toluene. The oral, acute LD_{50} for toluene in young, adult rats is reported to be 7.0 g/kg (Wolf, et al. 1956). It is possible that the actual "maximum-no-effect" dose may be lower than 590 mg/kg, should alternative indices of toxicity be evaluated. Man may prove to be more sensitive to toluene than experimental animals. Thus, assuming a 70 kg body weight, it seems appropriate that a safety factor of 1,000 be applied in the following calculation:

$$\frac{590\ \text{mg/kg} \times 70}{1000} = 41.3\ \text{mg/kg}$$

Therefore, consumption of 2/l of water daily and 18.7/g of contaminated fish having a bioconcentration factor of 20, would result in, assuming 100 percent gastrointestinal absorption of toluene, a maximum permissible concentration of 17.4 mg/l for the ingested water:

$$\frac{41.3\ \text{mg/day}}{(2\ \text{liters} + (20 \times 0.0187) \times 1.0} = 17.4\ \text{mg/l}$$

Toxaphene

Criteria Summary

Freshwater Aquatic Life. For toxaphene the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.007 μq/l as a 24-hour average and the concentration should not exceed 0.47 μg/l at any time.

Saltwater Aquatic Life. For toxaphene the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.019 μg/l as a 24-hour average and the concentration should not exceed 0.12 μg/l at any time.

Human Health. For the maximum protection of human health from the potential carcinogenic effects of exposure to toxaphene through ingestion of water and contaminated aquatic

organisms, the ambient water concentration is zero. Concentrations of toxaphene estimated to result in additional lifetime cancer risks ranging from no additional risk to an additional risk of 1 in 100,000 are presented in the Criterion Formulation section of this document. The Agency is considering setting criteria at an interim target risk level in the range of 10^{-5}, 10^{-6}, or 10^{-7}, with corresponding criteria of 0.5 ng/l, 0.05 ng/l, and 0.005 ng/l, respectively.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of toxaphene is the Final Acute Value of 0.47 μg/l and the 24-hour average concentration is the Final Chronic Value of 0.007 μg/l. No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For toxaphene the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.007 μg/l as a 24-hour average and the concentration should not exceed 0.47 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value=0.92 μg/l
Final Invertebrate Acute Value=0.46 μg/l
Final Acute Value=0.46 μg/l
Final Fish Chronic Value=0.007 μg/l
Final Invertebrate Chronic Value=0.06 μg/l
Final Plant Value=not available
Residue Limited Toxicant
Concentration=0.011 μg/l
Final Chronic Value=0.007 μg/l
0.44×Final Acute Value=0.20 μg/l

Saltwater Aquatic Life. The maximum concentration of toxaphene is the Final Acute Value of 0.12 μg/l and the 24-hour average concentration is the Final Chronic Value of 0.019 μg/l. No important adverse effects on saltwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For toxaphere the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.019 μg/l as a 24-hour average and the concentration should not exceed 0.12 μg/l at any time.

Summary of Available Data. The concentrations below have been rounded to two significant figures.

Final Fish Acute Value = 0.44 μg/l
Final Invertebrate Acute Value = 0.12 μg/l
Final Acute Value = 0.12 μg/l
Final Fish Chronic Value = 0.12 μg/l
Final Invertebrate Chronic Value = 0.019 μg/l
Final Plant Value = 0.15 μg/l
Residue Limited Toxicant
Concentration = 0.39 μg/l
Final Chronic Value = 0.019 μg/l
0.44 × Final Acute Value = 0.053 μg/l

Human Health. Various water concentrations of toxaphene have been recommended to protect man and aquatic organisms from the organoleptic or toxic properties of this compound (see "Existing Guidelines and Standards" section). These concentrations with the accompanying rationale, are summarized below:

Level:	*Rationale*
5.0 μg/l	Organoleptic effects
2.5 μg/l	Non-carcinogenic mammalian toxicity
8.75 μg/l	Non-carcinogenic mammalian toxicity
0.44 μg/l	Non-carcinogenic mammalian toxicity
0.008 μg/l	Aquatic toxicity data

Additionally, carcinogenic responses have been induced in mice and rats by toxaphene (National Cancer Institute, 1979).[1] These results, together with the positive mutagenic response, constitute substantial evidence that toxaphene is likely to be a human carcinogen. Estimated criterion levels for toxaphene in water can be calculated using the linear, non-threshold model described in the **Federal Register,** March 15, 1979, and the results of the National Cancer Institute bioassay of toxaphene for carcinogenicity (see Summary of Pertinent Data).

Under the Consent Decree in *NRDC v. Train,* criteria are to state "recommended maximum permissible concentrations (including where appropriate, zero) consistent with the protection of aquatic organisms, human health, and recreational activities." Toxaphene is suspected of being a human carcinogen. Because there is no recognized safe concentration for human carcinogens, the recommended concentration of toxaphene in water for maximum protection of human health is zero.

Because attaining a zero concentration level may be infeasible in some cases and in order to assist the Agency and States in the possible future development of water quality regulations, the concentrations of toxaphene corresponding to several incremental lifetime cancer risk levels have been estimated. A cancer risk level provides an estimate of the additional incidence of cancer that may be expected in an exposed population. A risk of 10^{-5} for example, indicates a probability of one additional case of cancer for every 100,000 people exposed, a risk of 10^{-6} indicates one additional case of cancer for every million people exposed, and so forth.

In the **Federal Register** notice of availability of draft ambient water

[1] National Cancer Institute. 1979. Bioassay of Toxaphene for possible carcinogenicity. DHEW Publication No. (NIH) 73-837

quality criteria, EPA stated that it is considering setting criteria at an interim target risk level of 10^{-5}, 10^{-6} or 10^{-7} as shown in the table below.

Exposure assumptions	Risk levels and corresponding criteria [1]			
	0	10^{-7}	10^{-6}	10^{-5}
2 liters of drinking water and consumption of 18.7 grams fish and shellfish[2].	0	0.005 ng/l	0.05 ng/l	0.5 ng/l
Consumption of fish and shellfish only..	0	0.005 ng/l	0.05 ng/l	0.5 ng/l

[1] Calculated by applying a modified "one hit" extrapolation model described in the FR 15926, 1979. Since the extrapolation model is linear to low dosses, the additional lifetime risk is directly proportional to the water concentration. Therefore, water concentrations corresponding to other risk levels can be derived by multiplying or dividing one of the risk levels and corresponding water concentrations shown in the table by factors such as 10, 100, 1,000, and so forth.

[2] 99 percent of the toxaphene exposure results from the consumption of aquatic organisms which exhibit an average bioconcentration potential of 18,000 fold. The remaining percent of toxaphene exposure results from drinking water.

Concentration levels were derived assuming a lifetime exposure to various amounts of toxaphene, (1) occurring from the consumption of both drinking water and aquatic life grown in water containing the corresponding toxaphene concentrations and, (2) occurring solely from consumption of aquatic life grown in the waters containing the corresponding toxaphene concentrations.

Although total exposure information for toxaphene is discussed and an estimate of the contributions from other sources of exposure can be made, this data will not be factored into ambient water quality criteria formulation because of the tenuous estimates and the conflicting information regarding the trend of toxaphene residues in food until additional analysis can be made. The criteria presented, therefore, assume an incremental risk from ambient water exposure only.

Summary of Pertinent Data

The water quality criterion for toxaphene is derived from the development of hepatocellular carcinomas and neoplastic nodules in the B C F male mice given the low dose of toxaphene in the NCI bioassay study. In that group, a time-weighted average dose of 99 ppm was administered in the diet for 80 weeks and the animals were observed for additional 10 weeks before terminal sacrifice. The incidence of hepatocellular carcinomas and neoplastic nodules was 7/48 and 40/49 in the pooled control and treated groups, respectively. Assuming a fish bioconcentration factor of 18,000, the criterion is calculated from the following parameters:

nt = 40
Nt = 49
nc = 7
Nc = 48
Le = 900 days
le = 665 days
d = 99 ppm × 0.136 = 13.50 mg/kg/day
w = 0.033 kg
L = 900 days
R = 18,000
F = 0.0187 kg/day

Based on these parameters, the one-hit slope (B_n) is 4.42 (mg/kg/day). The resulting water concentration of toxaphene calculated to keep the individual risk below 10^{-5}, is $4.f \times 10^{-4}$ micrograms/liter.

Zinc

Criteria Summary

Freshwater Aquatic Life. For zinc the criterion to protect freshwater aquatic life as derived using the Guidelines is "$_e$(0.67·ln(hardness) + 0.67)" as a 24-hour average and the concentration should not exceed "$_e$(0.64·ln(hardness) + 2.46)" at any time.

Saltwater Aquatic Life. For saltwater aquatic life, no criterion for zinc can be derived using the Guidelines, and there are insufficient data to estimate a criterion using other procedures.

Human Health. For the prevention of adverse effects due to the organoleptic properties of zinc, the current standard for drinking water of 5 mg/l was adopted for ambient water criterion.

Basis for the Criteria

Freshwater Aquatic Life. The maximum concentration of zinc is the Final Acute Value of $_e$(0.64·ln(hardness) + 2.46) and the 24-hour average concentration is the Final Chronic Value of $_e$(0.67·(hardness) + 0.67). No important adverse effects on freshwater aquatic organisms have been reported to be caused by concentrations lower than the 24-hour average concentration.

For zinc the criterion to protect freshwater aquatic life as derived using the Guidelines is "$_e$(0.67·ln(hardness) + 0.67)" as a 24-hour average and the concentration should not exceed "$_e$(0.64·ln(hardness) + 2.46)" at any time.

Summary of Available Data. All concentrations herein are expressed in terms of zinc.

Final Fish Acute Value = $e^{(0.67 \cdot \ln(\text{hardness}) + 3.63)}$
Final Invertebrate Acute Value = $e^{(0.64 \cdot \ln(\text{hardness}) + 2.46)}$
Final Acute Value = $e^{(0.64 \cdot \ln(\text{hardness}) = 2.46)}$
Final Fish Chronic Value = $(0.67 \cdot \ln(\text{hardness}) + 0.67)$
Final Invertebrate Chronic Value = $e^{(0.64 \cdot \ln(\text{hardness}) + 2.00)}$
Final Plant Value = 30 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = $e^{(0.67 \cdot \ln(\text{hardness}) + 0.67)}$

Saltwater Aquatic Life. No saltwater criterion can be derived for zinc using the Guidelines because no Final Chronic Value for either fish or invertebrate species or a good substitute for either value is available, and there are insufficient data to estimate a criterion using other procedures.

Summary of Available Data. The concentrations below have been rounded to two significant figures. All concentrations herein are expressed in terms of zinc.

Final Fish Acute Value = 9,000 μg/l
Final Invertebrate Acute Value = 41 μg/l
Final Acute Value = 41 μg/l
Final Fish Chronic Value = not available
Final Invertebrate Chronic Value = not available
Final Plant Value = 50 μg/l
Residue Limited Toxicant Concentration = not available
Final Chronic Value = 50 μg/l
0.44 x Final Acute Value = 18 μg/l

Human Health. Zinc is an essential element and is not a carcinogenic agent. Studies on experimental animals and on human beings given zinc for therapeutic purposes together with observations of occupationally exposed persons show that large doses of zinc can be tolerated for a long periods, provided that the copper status is normal.

Daily ingestion of about 150 mg of zinc as the sulphate has not resulted in adverse effects in most patients even after several months of treatment. A reduction of copper levels has been reported in patients with diseases such as sickle cell anemia and coeliac disease. A reduction of the dose of zinc and copper supplementation corrected the copper deficiency.

Laboratory animals have been shown to tolerate zinc concentration in the range of 100 to 300 mg/kg food and even higher for long periods when the intake of copper has been adequate. Copper deficient animals have been shown to be more susceptible. In many animal experiments zinc concentration in the diet of 1000 to 2000 mg/kg have been reported to be without effect. These concentrations should be compared to the average zinc content of human food, which is about 10 mg/kg.

The water quality criterion for zinc in water based on available data on effects of ingested zinc would be about 10 mg/l for the adult U.S. population. Assuming a water intake of 2 liters per day, this exposure would not cause more than an additional intake of 20 mg which can be well tolerated. This concentration is above the present standard for drinking water which is 5 mg/l based on organoleptic effects.

There are some indicationms that infants and small children may have a high intake of water and an additional intake of 10 to 20 mg might have an influence on copper metabolism in children with low copper intakes or with copper deficiency due to, e.g. intestinal diseases. However, due to insufficient amount of information available for this special group at risk, derivation of criterion lower than the current standard would be difficult to justify. Therefore, it is recommended that the current level be maintained for water quality criteria purposes (5 mg/l). As additional information becomes available reconsiderations of appropriateness of the current standard should be performed.

Acenaphthene	PB 296 782
Acrolein	PB 296 788
Antimony	PB 296 789
Chlorinated Phenols	PB 296 790
Copper	PB 296 791
Cyanide	PB 296 792
Dichlorobenzidine	PB 296 793
Dichloropropanes/propenes	PB 296 799
2,4 Dinitrotoluene	PB 296 794
Diphenylhydrazine	PB 296 795
Endosulfan	PB 296 783
Endrin	PB 296 785
Ethylbenzene	PB 296 784
Haloethers	PB 296 796
Halomethanes	PB 296 797
Isophorone	PB 296 798
Naphthalene	PB 296 786
Nickel	PB 296 800
Nitrobenzene	PB 296 801
Nitrophenols	PB 296 802
Phenol	PB 296 787
Phthalate Esters	PB 296 804
Polychlorinated biphenyls (PCB)	PB 296 803
Toluene	PB 296 805
Toxaphene	PB 296 806
Zinc	PB 296 807

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